The Proceedings of the Geophysical Society of Tulsa

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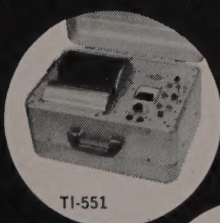
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PROCEEDINGS OF THE GEOPHYSICAL SOCIETY OF TULSA

Published Annually By The

GEOPHYSICAL SOCIETY OF TULSA, TULSA, OKLAHOMA

Volume 6, 1958-59

J. J. Roark, *Editor*

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EDITOR'S FOREWORD

Several changes have been made in the operations associated with the PROCEEDINGS OF THE GEOPHYSICAL SOCIETY OF TULSA. The White Advertising Agency was retained to handle the sale of advertising and arrangements were made with the Tulsa Book Shop to handle the public sales of the Proceedings. The first move was made to eliminate the need for a business manager, a position which has become increasingly difficult to fill. The book store arrangement was made in order to lighten the SEG office work load and to provide storage facilities for back issues. Colin Campbell and his staff have been very helpful in that they handled the sales of our back issues without charge. For this we offer our sincere thanks.

The technical content of this issue is devoted to geophysics in the Soviet Union. The editor prepared the article on SOVIET GEOPHYSICAL ACTIVITY from data found in the published literature. The other four articles are translations of older Soviet articles which were selected on the bases of not having been published in English and as giving some measure of the state of the art in the Soviet Union. The article by Gamburtsev is of special interest as it is one of the early papers on the subject. The local society is currently sponsoring some of this type of seismic work.

The section on ABSTRACTS OF PAPERS AND LECTURES GIVEN BEFORE OTHER LOCAL SECTIONS of SEG is far from being complete. The material presented herein was obtained from local section secretaries and the SEG Newsletter. There are currently twenty-four local sections.

To all who cooperated in this venture, especially to the advertisers, who tolerated an excessive delay in publication, the editor wishes to offer his thanks. He hopes that the Soviet material will be received as an effort to pass on information and not as an effort to present the Soviet activities in an especially favorable light.

IN MEMORIAM

First Honorary Life Member of GST Passes Away

Dr. William Schriever

Dr. William Schriever, Professor of Physics at the University of Oklahoma, died on November 20, 1958. He passed away in the University Infirmary at Norman, as the result of a malignancy of long standing, for which he underwent radical-major surgery in July of 1954.

Professor Schriever was the first Honorary Life Member of the Geophysical Society of Tulsa and had been elected the fourteenth Honorary Life Member of the Society of Exploration Geophysicists three months prior to his death. These two signal recognitions alone gave him much comfort and pleasure during his last illness.

Dr. Schriever was born January 16, 1894, at Dakota City, Nebraska. On August 16, 1922, he married the former Lucille E. Weisenbach of Edmond, Oklahoma, who survives him and still resides at the home in Norman, Oklahoma. Professor and Mrs. Schriever had two children, William W. Schriever, now a graduate student in physics at Harvard University, and, Elinor Marie Schriever, now Mrs. G. L. Scott of Houston, Texas. "G. L." is employed as a seismologist with the Atlantic Refining Company of Houston.

Dr. Schriever received his early education in Dakota City, where he was raised by his father and other relatives on his father's side of the family. As a boy he did a lot of hunting and fishing along the banks of the Missouri River. His interest in and talents for mechanics developed at an early age. He was quite dexterous in the development of mechanical devices and equipment on the farm where he spent most of his early years. He fashioned and developed many of his own tools, including a wood lathe.

During his college years, Dr. Schriever operated his own watch and clock repair business to help meet his college expenses. As a result of this activity he became an authority on clock and watch movements and gained a profound knowledge of old and rare time pieces. His interest in accurate time measuring devices and instruments continued throughout his career.

Professor Schriever received his B. A. degree from Morningside College in 1916, where he majored in physics and taught elementary physics laboratory classes during his Senior year. He then entered graduate training in physics as a Scholar at the University of Iowa, where he received his M. S. degree in 1917. He was then made a Fellow and continued his graduate studies in physics at Iowa during 1917-18.

World War I interrupted his education, as he was chosen one of the very few selected for training at what is now the Bell Telephone Laboratories, in the then new field of airplane-to-ground wireless communication. After six months of training for this work, he was stationed at Camp Alfred Vail, now Fort Monmouth, flight testing the crude instruments available in those days. On one such flight test he was able to establish communication over New York City.

After World War I Dr. Schriever returned to the University of Iowa as a Fellow in Physics in 1918-19. He interrupted his graduate studies once more when he went to the University of Oklahoma with Dr. Homer L. Dodge, who became Head of the Physics Department after the resignation of Dr. Wm. P. Haseman, who joined with Dr. J. C. Karcher and Dr. Irving Perrine in conducting the very first experimental work which led to the development of the reflection seismograph. It was this early pioneer work of Drs. Haseman, Karcher, and Perrine that turned Professor Schriever's interest toward geophysics.

Pofessor Schriever returned to Iowa in the fall of 1920 and received his Ph.D. in the spring of 1921. He then returned to his Assistant Professorship in Physics at the University of Oklahoma, where he was made Associate Professor in 1924, and Professor in 1927. He was later Chairman of the Physics Department (1942-52), and Director of the School of Engineering Physics (1942-48).

The Physics Department grew rapidly at O. U. in the 1920's and '30's. Many of its innovations in those early years are credited to Dr. Schriever's inventive and mechanical dexterity. He established and developed the Physics Shop from its inception and even during the depression managed to obtain the finest pieces of shop equipment available. One of his first purchases was a Rivett Lathe which is still in regular use. He was responsible for establishing the Physics Library, including the purchase of all back volumes of important journals. He designed many novel pieces of laboratory equipment, including the Inertial Balance now manufactured by Cenco. Dr. Schriever invented a projector table which folds into a lecture desk, a description of which was published in SCIENCE. He also developed a demonstration lift apparatus that used a vacuum cleaner for power, which would lift three men off the floor simultaneously. In the early 1940's much of Dr. Schriever's spare time was devoted to the planning and design of the present Research Institute-Physics building, in which the Physics Department is now located.

In the days before the advent of Geiger Counters and Scintillometers, Dr.

Schriever on many occasions would travel to the larger near-by cities at the call of the medical profession to retrieve lost radium needles which, in most cases, were found in the city garbage dump. He accomplished this by means of a special electroscope which he developed for this purpose.

In 1924 he initiated the first course in geophysics to be taught in the State of Oklahoma. In those early days there were no text books in English on the subject, and he used for class lectures his own notes, which he based mostly on the German literature. He continued teaching this course, "Applied Geophysics", until his death. Over the twenty-nine years he offered the course, a total of 408 students were enrolled in it. Two hundred and eighty of these are listed as members of the Society of Exploration Geophysicists, and many of them are now leaders in the geophysical industry.

In his citation for Honorary Life Membership awarded to Dr. Schriever by The Geophysical Society of Tulsa, President Frank Searcy stated, "In recognition of the high esteem in which Dr. Schriever is held by former students and others who knew him and are familiar with his work, The Geophysical Society of Tulsa considers it an honor and a privilege to make him the first Honorary Life Member of our Society as is his just due as 'Dean of Geophysics' in the State of Oklahoma".

In addition to his teaching and administrative duties in the Physics Department at O. U., he found ample time to direct and guide many a graduate student on his research project. Dr. Schriever is well known in scientific circles for his fundamental researches and thirty-nine publications in various technical journals on such subjects as: space charges in conducting electrolytes, electromotive force in oral cavities, electrokinetic phenomena and electricity. He is best known in geophysical circles for his hypothesis of the meteoric origin of the Carolina Bays, and his several publications on that subject. He has published several papers relating to seismic prospecting, including two in Volume 4 of this journal. Other important papers relating to geophysics are: Law of Flow for a Gas-Free Oil Through a Spherical-Grain Sand and Streaming Potential in Spherical Grain Sands. His last publication, Para and Diamagnetic Susceptibilities in Non-Fluctuating Weak Fields, appeared in GEOPHYSICS (October, 1958) just a month prior to his death.

Dr. Schriever was a Fellow of American Physical Society, American Association for the Advancement of Science, Oklahoma Academy of Science and a member of American Association of Physics Teachers, American Geophysical Union, Sigma Xi, Sigma Pi Sigma, Gamma Alpha, and Sigma Gamma Epsilon. He was a Research Fellow of the American Petroleum Institute during 1927-29, and Director of the State Bureau of Standards from 1942 until his death.

In his citation for Honorary Life Membership in the Society of Exploration Geophysicists, President E. V. McCollum, one of his former students stated, "This award to Dr. William Schriever is being made in recognition of his scholarly contributions in teaching, research, and scientific papers devoted to geo-

physics and allied fields. Our present international situation demands that we produce superior scientists in greater numbers. One of the prime requisites of such a program is outstanding teachers. Several hundred former students of Dr. Schriever, who are now members of SEG, will attest to his scholarly, dedicated, practical, and inspirational manner of teaching. He has, therefore, made a distinguished contribution to the world of science by the character of his teaching, his original researches, and his writings."

During the past two yuletide seasons the hearts of many of us have been saddened by not receiving the Annual Christmas Letter sent out by Dr. and Mrs. Schriever to his many former students each year. This annual message from him had become a tradition which he started some thirty years ago. It usually contained three pages mimeographed on both sides and contained news of the Physics Department, details of the growth of the University, and a wealth of personal information, such as marriages, birth, deaths and changes of employment of former students, etc. Its circulation was worldwide.

The holiday season always brought to light another one of Dr. Schriever's many talents — his success with "saddle waffles". He devoted about two days each year to preparing vast heaps of sweet little pastries for the Departmental Christmas Party.

Although I never knew him to attend church or any religious function, he was not without faith. As a graduate student at Iowa, Dr. Schriever was a member of the Unitarian Church whose pastor, Dr. Charles M. Perry, later became Head of the Department of Philosophy at the University of Oklahoma. During the thirty-seven years it was my privilege and good fortune to know him personally, and to have him for a teacher and advisor during my undergraduate studies at O. U., I never heard him utter a profane word. To those of us who knew him best, he truly emulated the philosophy of the Master Teacher. No matter how pressing his task or duties may have been at the moment, he was always ready to stop and lend a helping hand or give a few words of wise counsel. As one of his former students who later became an eminent physician remarked several years ago, "People like Bill Schriever are the salt of the earth." No other descriptive words could more aptly be spoken of Dr. William Schriever.

V. L. Jones

SOVIET GEOPHYSICAL ACTIVITY

When we study the annual review of geophysical activities in GEOPHYSICS, we wonder about similar activities in the Soviet Union. Recently, the available Soviet literature was reviewed for information on this subject, with this article as the result.

As the larger part of the information available concerned total geophysical effort and seismic activity, only these categories are reported in this article. Other methods of exploration reported in part were gravimetric, magnetic, electrical and gas analysis. The first Soviet geophysical exploration effort for oil was the use of two gravity crews in 1925. (1) The first use of electrical and seismic methods occurred in 1929 and a magnetic method was used in 1930. Gas measuring techniques were introduced in 1933 when five crews were in operation.

Data on the number of Soviet field crews were found in three articles (1, 2, 3). The oldest reference (1) had data for the period 1925-1935. The other references (2, 3) cover the period 1940-1958. These data are tabulated in Table I along with data for the U.S.A. and the Free World from GEOPHYSICS. The data are shown in Fig. 1.

It appears that the Soviet seismic exploration effort is comparable to the present American effort and has overcome a 10-to-12 year lag which has persisted since the early thirties. It would also appear that the Soviet geophysicists have difficulties that would sound familiar to their American counterparts.

There is mention of low efficiency in the field work and of quotas not met. A few examples follow.

Reference 4, page 405:

> "In Siberia, the volume of exploration and geophysical work and prospecting drilling continued to grow. This volume, however, is clearly small. As usual, the geophysical work and prospecting drilling fell behind."

Reference 4, page 408:

> "Losses of time of organizational idle standing amounts to as much as 30% of the total time of the prospecting drilling. The economic effectiveness of prospecting work in a number of regions is low. For the last two years, the expenditure per ton increment of oil and gas reserves has increased. One of the causes of the reduction of the effectiveness of prospecting is the lag in testing of wells."

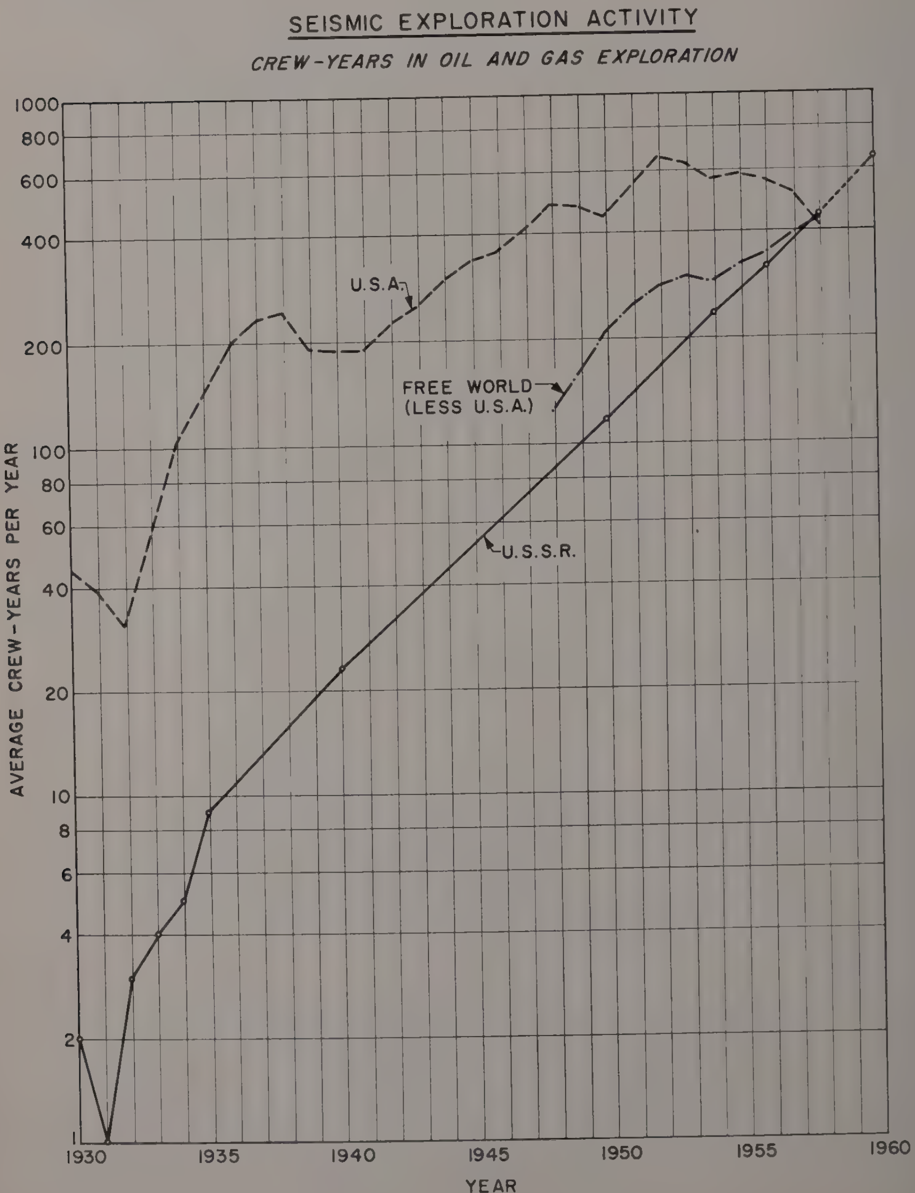
Reference 5, page 3:

> "We must say frankly that in spite of known achievements in the methods of preparation and interpretation, the seismological exploration is rather inadequate for solving the structural-prospecting problems in parts of the Volga-Ural oil-gas fields and in Western Siberia.
>
> "There is a tendency, not always justified, to increase the average depth of structure (core) wells without any connection between

structural problems of deep geological structures and the search for oil and gas."

Reference 6, page 127:

"Field geophysical projects are planned according to the principle of a centralized determination of a compulsory volume of geophysical work. The volume of geophysical work is set as obligatory for each party and is regulated strictly according to time, that is,

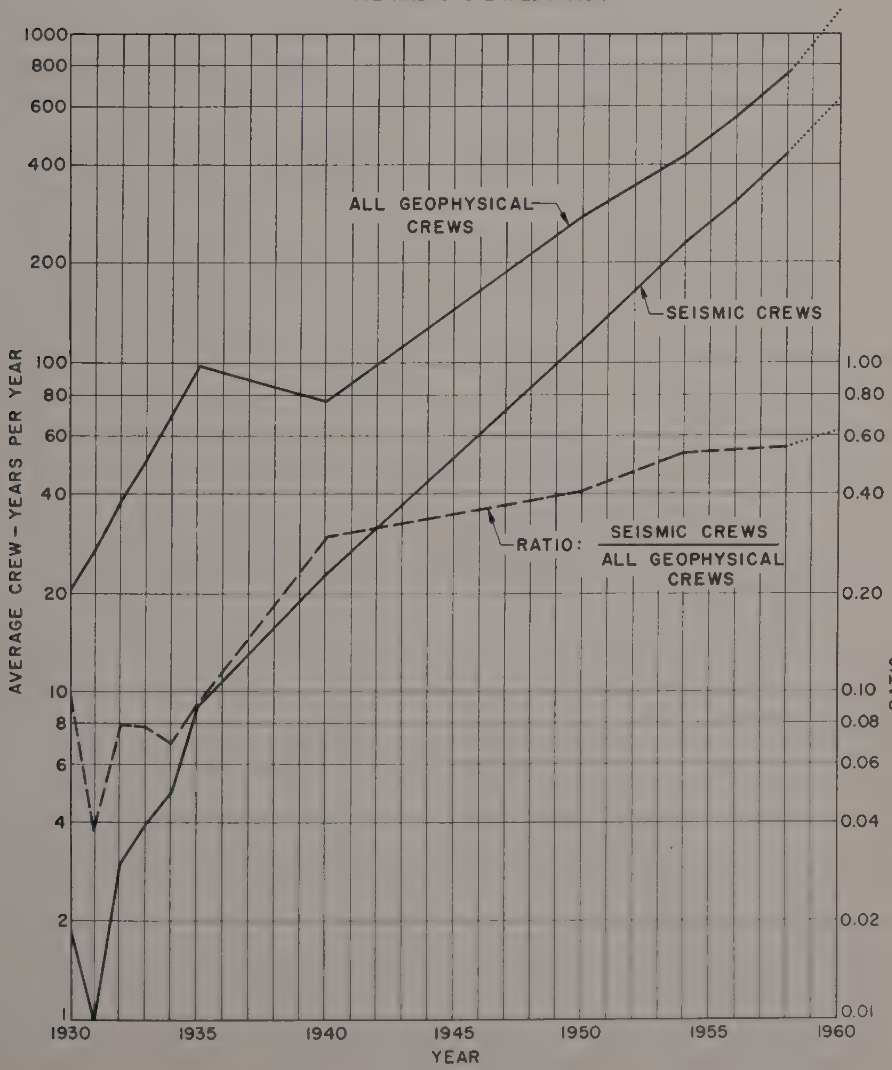


according to months of field work. Such an arrangement combines the initiative of the engineering-technical staff of the field parties such that instead of concentrating effort on successful solution of the main exploration problems, they turn all their attention to the building up the volume of work. The increase of volume of work in field investigations, as a result of such practices, becomes the main goal of geophysical field parties; they are not concerned with what is or is not necessary to raise the volume of work in the interest of solution of the main problems that develop in the technical project."

Management does not make good use of geophysical methods. Instead,

SOVIET GEOPHYSICAL ACTIVITY

OIL AND GAS EXPLORATION



they place too much reliance on drilling and surface geology. Also, their seismic equipment has been undergoing evolution. In 1955 (2), they announced the introduction of 60-channel recording equipment. In 1959 (3) the 60-channel equipment was being superseded by portable 24-channel equipment and magnetic tape recording was introduced. Some of these changes are reflected in the cost and personnel figures of Table II.

The unique organization of the Soviet system permits close control over the growth of their exploration effort. Although, they may not achieve their goals, it is interesting to look at their announced plans. Data from three articles on the subject of growth (6, 7, 8) were combined with part of the data in Table I to obtain Fig. 2. This shows an increasing emphasis on geophysical exploration with a larger seismic effort. In 1958, the Soviet seismic effort, expressed as a percentage of the total effort, was 57 per cent. This compares with 88 per cent as the corresponding U.S.A. figure. The estimate of 653 seismic crews in 1960 appears to be reasonable. The current Seven-Year Plan calls for about 1500 seismic crews to be engaged in exploration for oil and gas in 1965.

TABLE I

SOVIET SEISMIC ACTIVITY – CREW YEARS PER YEAR

Year	U.S.A.	Free World (Less U. S. A.)	U. S. S. R.
1930	45	—	2
1931	39	—	1
1932	31	—	3
1933	58	—	4
1934	105	—	5
1935	144	—	9
1936	200	—	—
1937	234	—	—
1938	246	—	—
1939	191	—	—
1940	189	—	23
1941	189	—	—
1942	226	—	—
1943	251	—	—
1944	297	—	—
1945	339	—	—
1946	363	—	—
1947	413	—	—
1948	487	126	—
1949	481	161	—
1950	447	210	118
1951	545	251	—
1952	663	284	—
1953	639	302	—
1954	572	290	237
1955	591	325	—
1956	568	353	321
1957	524	398	—
1958	422	439	447
1959	—	—	—
1960	—	—	653 (est.)
1961	—	—	—
1962	—	—	921 (est.)
1963	—	—	—
1964	—	—	1287 (est.)
1965	—	—	1511 (est.)

TABLE II

SOVIET SEISMIC CREW DATA

Year	Persons/crew	Cost per crew–mo.		Line per crew–mo.		Cost per unit length	
		Rubles	Dollars*	Kilometers	Miles	Rubles/KM	Dollars/mile*
1947	22	—	—	—	—	—	—
1948	23	—	—	—	—	—	—
1949	27	—	—	—	—	—	—
1950	32	—	—	36.2	22.5	—	—
1951	35	144,000	28,800	41.3	25.6	3,491	1,123
1952	37	147,000	29,400	39.1	24.3	3,750	1,207
1953	46	178,000	35,600	31.2	19.4	5,714	1,839
1954	48	173,000	34,600	28.1	17.5	6,163	2,043
1955	46	183,000	36,600	32.0	19.9	5,705	1,836

*Rubles converted to Dollars in the ratio of 5 to 1.

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   (Petroleum Geology is an English translation of Geologiya Nefti)

SEISMIC PROBING OF THE EARTH'S CRUST

By
G. A. Gamburtsev*

The internal constitution of the Earth is studied by an array of geophysical methods, and seismological methods (which involve the recording of earthquakes) are among these. These seismological methods, however, are valuable enough for over-all investigations of the Earth's interior, but they are not precise enough for detailed investigations of the crust.

A considerable amount of detail can be obtained by means of seismological methods that involve the recording of waves that radiate from small explosions, but these methods are suitable only for the investigation of the upper layers of the crust. The recording of waves from large industrial blasts(1) yields information about much greater depths, but one cannot base systematic investigations upon these blasts, inasmuch as systematic investigation presupposes the opportunity to repeat the blast, and (more important) the opportunity to select blasting sites dictated by geophysical problems.

This is why, in 1939, the energies of the Theoretical Geophysics Institute of the Academy of the USSR were directed to the problem of increasing the depths to which reflection shooting methods can penetrate, by increasing the actual sensitivity of the recording seismographs(2).The difficulties involved in separating out individual reflected wave trains, however, worked against progress toward any positive results. All further investigations of deep reflection shooting (GSZ) (3) techniques were carried out by means of refraction correlation shooting (KMPV) (4) methods that were being developed at the same time.

The fundamental problem, at that stage of our work, was to increase the distances at which elastic waves could be recorded, and upon which depth penetration measurements depend. This problem was solved, in 1949, in the northern Tian-Shan Ranges. The results obtained there permitted us to address ourselves to problems that are geophysical, and not merely methodological. A great deal of attention was paid to problems that are involved in earthquake forecasting (5).

Our deep reflection shooting operations were carried out with the kind of equipment that is used in exploratory correlation shooting. Our seismographs were modified, however; their range was extended in the low frequency direction, in order to permit a variation of the pass band. We established, experimentally, that a 10 cycle (per second midband) frequency was best for long distance detection of longitudinal waves. The frequency should be even lower for good (long distance) detection of shear waves produced by explosions.

Both the selectivity and the output power (gain) of the amplifiers were increased, in order to increase the sensitivity of our seismographs. Preliminary experiments were carried out with various spacings of the instruments in our detector spread, in order to insure the most sensitive recording (6). Particular attention was paid to time mark control, inasmuch as it was necessary to record incoming waves continuously over intervals of several minutes.

* Corresponding member of The Academy of Sciences of the USSR. A translation of the original article which appeared in Doklady Akademii Nauk SSSR, v. 87, no. 6; December, 1952.

We carried out our recording of seismic waves, in the Tian-Shan Range, at a shot distance of 400 km. Reception of waves, at such long shot distances, from comparatively weak explosions, was due to the improved detector response which we mention above, to good transmission conditions (shooting was carried out at night, in the main, and far from inhabited areas), and to good shooting arrangements (shot holes were between 20 and 25 meters deep, and the charges were tamped with water).

Two groups of waves, which we term B and C, stand out in the entire collection of seismograms recorded at shot distances of 240 or 250 km. There is a substantial difference between the apparent velocities of the two groups, even though the range of apparent velocities, within each group, is very small. The apparent velocities, for group B, are predominantly of the order of 6 or 7 km./sec., while the apparent velocities for group C are of the order of 8 or 8.5 km/sec. These wave groups stand out with an especial sharpness at shot distances of 300 or 400 km.; at these distances difference in travel times are also sharp.

A comparison with earthquake seismograms leads one to surmise that the B group consists of P^* waves, which follow the upper surface of the basaltic layer, and the C group consists of P_n waves that travel along underside of the Mohorovicic discontinuity. It is most interesting that the P^* and P_n waves, that dominate earthquake seismograms, should be also as predominant as they are at the higher frequencies that are generated by blasts. The fact that the P^* and P_n phases were represented by wave trains rather than isolated waves, in our seismograms, is a consequence of the higher frequencies and makes for an unequivocal record.

Our deep reflection shooting operations, during 1949 and 1950, were carried out by means of continuous detector profiles, as well as by means of isolated spreads. Profiles up to 25 km. in length gave us the opportunity to establish the basis upon which reflections can be correlated, and the structure of waves and wave trains. Good identification of waves and wave trains was obtained, in areas with simple geologic structure, by means of 20 km. seismograph profiles in which the spacing between the instruments was 200 meters or more. Such good identification was not obtained in all cases, however. Strong interference effects would appear in groups of waves with closely grouped apparent velocities. There were cases in which marker beds would be lost within the limits of a single seismogram, in mountainous districts. But even such seismograms give valuable information about the deep crustal discontinuities. We can take, as an example, a seismogram recorded at Karabalty Village, in the foothills of Kirghiz Range, 200 km. from the shot point (at Lake Issyk-Kul'). The reflecting (marker) formations show very wide variations of dip, in this seismogram, and the amplitudes of the reflected waves change sharply over short distances (of the order of hundreds of meters). If we fall back upon analogies with refraction correlation shooting, in order to obtain an explanation, we infer that we are dealing with waves that are diffracted by structures deep within the crust (escarpments, vertical discontinuities, etc.).

We discovered that it was possible to treat isolated seismographs, placed at distances of 20 or 30 km. from each other, as belonging to a single spread in regions with simple geologic structure. This was done by means of a wave correlation analysis that involved (1) actual travel times, (2) the apparent velocities of the several wave groups, determined for every profile and every

isolated seismograph, and (3) the ratio among the amplitudes of the various wave types.

The fact that the various wave groups are readily identifiable at large shot distances facilitates this kind of correlation, and permitted the plotting of travel time curves for every direction in which profiles were shot.

Travel time curves that corresponded to earthquake seismology curves for P^* and P_n waves were plotted from the records of four profiles that were shot during 1949 and 1950. P^* and P_n travel time curves were plotted for two profiles that extended from Lake Issyk-Kul' to Lake Balkhash (shot point at Lake Issyk-Kul'), and overlapping curves were plotted for a profile with a shot point at Lake Kara-Kul'. The agreement among the curves cannot be questioned; this confirms, again, our identification of the waves.

A comparison of our P^* and P_n travel time curves with those plotted by E. A. Rozova (7) for natural earthquakes in Central Asia (on the assumption that the focus is located at the epicenter) revealed considerable agreement of travel times and apparent velocities. The difference between our travel times and Rozova's are of the order of a few seconds, and occasionally as much as 5 seconds.

These differences, however, indicated thicknesses obtained by Rozova. Specifically, we obtained a thickness, for the granitic layer, between 10 and 15 km., and a thickness between 30 and 40 km. for the basaltic layer, in the northern portions of the area under investigation. We should note, here, that Rozova obtained an opposite result: her values, for granitic layer thickness, exceeded her values for the basaltic layer. These differences can be due to local variations in crustal structure. One piece of evidence, that supports such conclusion, is our finding that the upper surface of the basaltic layer and the Mohorovicic discontinuity dip sharply to the south (from Lake Balkhash to the Kirghiz Mountains). It follows, incidentally, that earthquake foci (especially near-quake foci) cannot be located accurately by averaging wave data over a large area; our findings indicate that significant differences can exist among travel time curves plotted for profiles shot in different directions.

The fundamental result of our investigation is the finding that deep reflection shooting has developed to the point where it can be used for the exploration of the deeper portions of the crust: this releases the seismologist from his dependence upon large scale industrial blasting.

Deep reflection shooting permits seismology to study those crustal levels at which earthquake foci are found. This simply means that deep reflection shooting must play a greater role in earthquake seismology and geophysical exploration.

We shall show elsewhere that the application of deep reflection shooting, in other regions, can lead to travel time curves for near earthquake foci.

Submitted Oct. 13, 1952

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A COMBINED PLOT METHOD FOR DETERMINING THE RANGE OF REFRACTURED AND REFLECTED WAVES

By

I. S. Berzon*

ABSTRACT

A method of determining the zones of refraction and reflection, for the same velocity discontinuity, is developed on the basis of travel time curves plotted for mean velocities. The waves are treated as reflected over the entire length of the detector spread, however.

The quantitative analysis of the seismograph records for a given wave propagation boundary requires that the propagation zones, for refracted and reflected waves, be delineated. The need for such a delineation grows out of the fact that the respective travel time curves, for refracted and reflected waves, are based on different calculation procedures.

These propagation zones, however, cannot be delineated directly from seismograms in those rather common cases in which the change from refracted to reflected waves, in the vicinity of the shot point, is not accompanied by a noticeable change in the [recorded] waves' dynamic properties (1). In such cases, the delineation of the propagation zones must be accomplished in another manner—for example, by comparing travel times with the values on a theoretical travel time curve for reflected waves, and obtaining a combined reflection-refraction travel time plot in this manner (1, p. 123), or on the basis of cross-sections obtained on the basis of combined travel time curves (1, p. 228).

A method of delineating the zones of propagation, for refracted and reflected waves, is developed in the present article; it is based on the mean velocity values given in combined travel time charts. We know, of course, that the determination of mean velocities, from reflection travel time curves, is a necessary step in record interpretation by means of wave reflection data (2, 3), as well as by means of combined (reflection-refraction) travel time curves (1). If one uses a set of combined curves in velocity determinations, and the position of the first (refraction) break, on the chart, is not established by other means, certain sections of the curve can be mistaken for continuation of the travel time curve for reflected waves, and wrong velocity values obtained.

The method that is developed below involves the difference among the mean velocities obtained from various portions of a combined travel time chart. These respective portions of the chart, to be sure, give travel times for refracted and reflected waves, but we shall assume, here, that the entire curve which we use gives reflection travel times.

We will consider the simplest case—that of a horizontal velocity boundary. The velocities, in overburden and bedrock, are V_1 and V_2 respectively.

* A translation of the original article which appeared in Izvestia Akademii Nauk SSSR, Ser. Geof.; No. 3, 3: 209-214; 1953.

In this case, the travel time for a reflected wave is given by the equation

$$t = \frac{(x^2 + 4H^2)^{1/2}}{V_1} \qquad (1)$$

where H is the depth of the discontinuity.

The equation for the travel time of a refracted wave is

$$t = \frac{x}{V_2} + \frac{2H\cos i}{V_1} \qquad (2)$$

where the critical angle $i = \arc \sin (V_1/V_2)$.

The travel time curve, for refracted wave, is tangent to the curve for a reflected wave at the point

$$x_H = 2H \tan i \qquad (3)$$

which is the shot distance for the critical ray.

The various methods developed in references (2) and (3) are used to determine the velocity V_1 from reflection travel time curves. In the last analysis, however, the choice of the method by which the mean velocity is calculated is immaterial, inasmuch as the velocity that is obtained by treating a refraction travel time curve as a refraction curve is independent of the type of mean.

We shall utilize curves obtained by plotting the squares of travel times against the squares of shot distances; this is a simple and clear presentation of the fundamental properties of the mean wave velocities.

Let us examine the manner in which the combined travel time curves transform on a system of coordinates in which $u(=x^2)$ is plotted against $w(=t^2)$.

The travel time for a reflected wave, is given by the equation

$$w = \frac{u + 4H^2}{V_1^2} \qquad (4)$$

and the derivative du/dw is equal, numerically, to the square of the overburden velocity — i.e.,

$$\frac{du}{dw} = V_1^2 \qquad (5)$$

The travel time of a refracted wave, in our quadratic system of coordinates, is given by the (parabolic) equation

$$w = \frac{u \sin^2 i + 4Hu^{1/2} \sin i \cos i + 4H^2 \cos^2 i}{V_1^2} \qquad (6)$$

The plot of this equation, of course is tangent to the plot of equation (4) at the shot distance for the critical ray.

The wave velocity calculated from the first derivative of equation (6) will be a variable and a function of shot distance, inasmuch as the travel time plot refracted waves on the quadratic coordinates, is a curve. Let us call this the mean apparent velocity, $V_{1\phi}$. $V_{1\phi}$ is connected with the velocity equation (6) by means of the equation

$$\frac{du}{dw} = V_{1\phi}^2 = \frac{V_1^2}{\sin^2 i + \frac{H \sin 2i}{u^{1/2}}}$$

Equation (6) shows that, in the system of quadratic coordinates, the travel time curve, for refracted waves, is determined by three parameters: the velocity V_1, the ratio of V_1/V_2 and the overburden depth H. This is why this system of u-w coordinates will permit us to examine the properties of refraction travel time curves, and their relationships to reflection curves for only one variable parameter (let us say $V_1/V_2 = \sin i$); the other two parameters (V_1 and H, for example) must be given. We can utilize a single common graph, to investigate the properties of travel time curves for various values of V_1, H and V_1/V_2, if we utilize the dimensionless coordinates

$$p = \frac{u}{H^2} = \frac{x^2}{H^2} \tag{8}$$

$$q = \frac{V_1^2 w}{H^2} = \frac{V_1^2 t^2}{H^2}$$

The parabolic travel time curve for reflected waves, given by equations (4) and (6) becomes a straight line with a 45° slope in the quadratic system of coordinates. The rectilinear travel time curve for refracted waves, on the other hand, becomes a parabola, and is tangent to the reflected wave curve at $p=4 \tan^2 i$ (the shot distance for the critical ray).

Figure 1 shows travel time curves for reflected and refracted waves, plot-

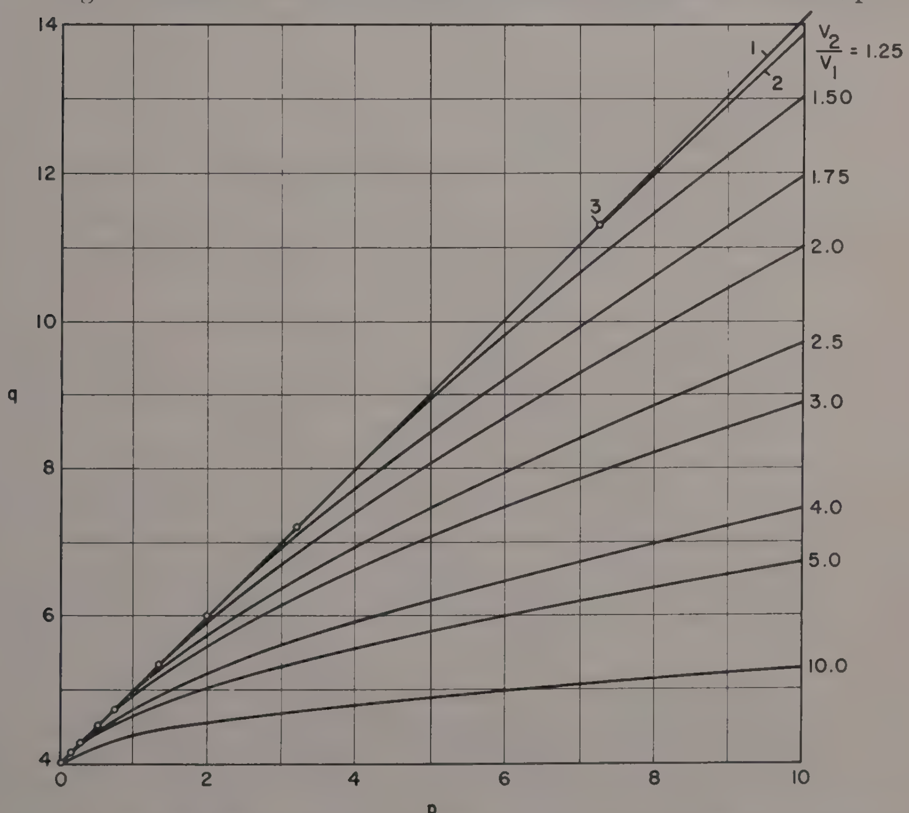

FIGURE 1: Combined travel time curves, for reflected and refracted waves, plotted in p-q coordinates. 1. Travel time curve for reflected waves. 2 Family of curves plotted for variable V_1/V_2. 3. First refracted arrival.

ted in the p-q system of coordinates, for various values of the ratio V_2/V_1. Note that we can utilize Figure 1 and equations (8) to plot travel time curves, for reflected and refracted waves, in the u-w system of coordinates for any values of H and V_1.

Figure 1 also shows that the change in the travel time curve, consequent upon a change from reflected to refracted waves, becomes sharper as the ratio V_2/V_1 increases.

Equations (8) also show that the derivative dp/dq, for a tangent to a combined reflection-refraction travel time curve plotted in the p-q coordinates, can be transformed to the u-w coordinates by means of the equation.

$$\frac{dp}{dq} = \frac{1}{V^2}\frac{du}{dw} \tag{9}$$

The value of the derivative du/dw is given by equation (5) for reflected waves, and by equation (7) for refracted waves. Consequently, the derivative is

$$\frac{dp}{dq} = 1 \tag{10}$$

for a tangent to the reflection portion of a combined travel time curve, and

$$\frac{dp}{dq} = \frac{V_{1\phi}^2}{V_1^2} \tag{11}$$

for a tangent to the refraction portion.

In other words, the slope (the first derivative) of a refraction travel time curve of the type plotted in Figure 1 evaluates the ratio $V_{1\phi}/V_1$. It follows, from equation (7) that this ratio can also be evaluated by means of the equation

$$\frac{V_{1\phi}}{V_1} = \frac{1}{\left(\sin^2 i + \frac{H \sin 2i}{x}\right)^{1/2}} \tag{12}$$

Equation (12) shows that the ratio $V_{1\phi}/V_1$ is a function of x/H and the critical angle i - i.e., the velocity ratio V_1/V_2. $V_{1\phi}/V_1$ approaches V_2/V_1 as x/H approaches infinity; therefore $V_{1\phi}$ approaches V_2 assymptotically. Figure 2 is a plot of $V_{1\phi}/V_1$ against x/H for various values of V_2/V_1 (= cosec i). The graph shows that $V_{1\phi}/V_1$ increases with increasing x/H, and the rate of increase is greatest in the vicinity of the shot distance for the critical ray. Also, the greatest increase in the apparent velocity $V_{1\phi}$ is obtained for large values of the velocity ratio V_2/V_1. Thus, for example, $V_{1\phi}/V = 1.50$ if $V_2/V_1 = 3.0$ and $x/H = 2.0$. If the values of V_2/V_1 are large, the plot of equation (12) will approach its assymptote only for very large values of x/H. Thus, for $V_2/V_1 = 10$, we will have $V_{1\phi}/V = 5.75$ even if $x/H = 10$; consequently, $V_{1\phi}$ is 42.5% off its assymptotic value, $V_2 = 10V_1$.

The apparent velocity, $V_{1\phi}$, increases with distance less rapidly for small values of V_2/V_1; it approaches its assymptotic value more rapidly, however, inasmuch as the difference between V_1 and V_2 is not great. Thus, we have $V_{1\phi}/V_1 = 1.20$ if $V_2/V_1 = 1.5$ and $x/H = 2$, and we have $V_{1\phi}/V_1 = 1.4$ if $x/H = 10$ - i.e., $V_{1\phi}$ will be only 7% off its assymptotic values $V_2 = 1.5V_1$.

Note that the overburden velocity, V_1, is generally evaluated as the slope of a segment of a rectilinear plot, and not as the first derivative of a curve;

the slope of the rectilinear segment is a sufficiently good approximation of the first derivative. The length of the segment that can serve as a good approximation decreases, however, as the rate of growth at which $V_{1\phi}/V_1$ increases (with increasing x/H) becomes larger. This approximation of the velocity value will be a mean value, averaged over the adjacent apparent velocity values on the curve.

An analysis of Figures 1 and 2 shows that the propagation zones for reflected and refracted waves, can be delineated on the basis of the slopes of curves plotted in quadratic coordinates, and also on the basis of the increase in the apparent velocity ratio, $V_{1\phi}/V_1$, as shown by the plot of this ratio in Figure 2.

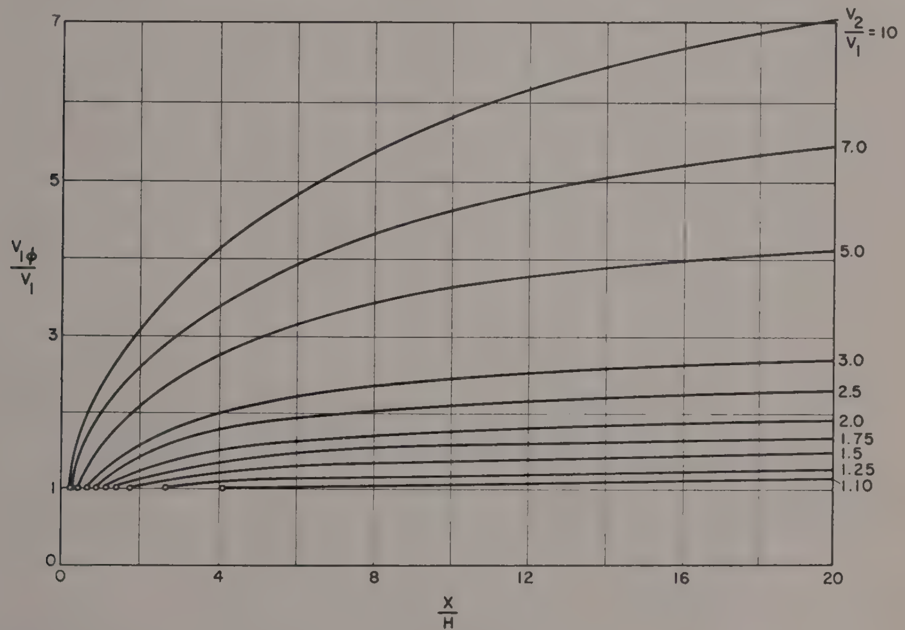

FIGURE 2: Plots of $V_{1\phi}/V_1$ against x/H for various values of V_2/V_1.

The provision with which these propagation zones can be delineated depends upon the velocity ratio V_2/V_1. The delineation is carried out with the greatest ease and certainty if the difference between V_2 and V_1 is considerable—i.e., if V_2/V_1 is greater than 2.

The maximum change in the slope of the (combined) travel time curve will locate the shot distance for the critical ray, in this case. Consequently, the greatest increase in the apparent velocity, $V_{1\phi}$, will also locate this shot distance.

The records upon which our studies were based were recorded with a limited number of seismographs, separated by measured [considerable] distances. This is why one can overlook the intersection of the travel time curves, for reflected and refracted waves, and draw the erroneous inference that the travel time curve has a point of inflection where refracted waves replace reflected as first arrivals, if the change in the slope of the curve is sharp in the vicinity of the critical ray shot distance, and the number of seismographs

is small. This type of error is possible especially if the value of the ratio V_2/V_1 is large.

The delineation of propagation zones, for reflected and refracted waves, is less certain when the ratio V_2/V_1 is small (between 1.5 and 2). The location of the critical ray shot distance is difficult, under these conditions, and one can only distinguish a zone (sometimes quite broad) in which refracted waves begin to replace reflected waves, as first arrivals.

The difference between $V_{1\phi}$ and V_1 will lie within the range of error that is allowable in the determination of V_1 if the difference between V_2 and V_1 is small (V_2/V_1 less than 1.5). Thus, for example, we will have $V_{1\phi}/V_1 = 1.12$ if $V_2/V_1 = 1.25$ and $x/H = 3.0$—i.e., the apparent velocity $V_{1\phi}$ will differ from V_1 (the true overburden velocity) by only 12%. This is why the velocity criteria, which we have examined, cannot be used to delineate propagation zones, for reflected and refracted waves, in those cases in which the difference between V_2 and V_1 is small. These propagation zones can be delineated only only the basis of the dynamic properties of the waves, in such cases. Consequently, the investigation of wave dynamics, in the neighborhood of shot distances for critical rays, is of great importance in areas in which the differences between the velocities of propagation for various formations, are small.

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Academy of Science of the USSR
Geophysical Institute

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MASS AREAL SEISMIC EXPLORATION IN THE CARPATHIANS*

by

V. D. ZAV'YALOV

There are two zones within the explored part of the Soviet Carpathian foot hills in which industry is interested at the present time: the outer zone of the Carpathian foot-hills downwarping where numerous gas deposits have been discovered (Dashava, Bilche-Volitsa, and others), and the inner zone where the oil deposits of the Carpathian foot hills are located.

The inner (oil) zone of the Carpathian foot-hills downwarping has a particularly complicated subsurface structure. The overthrusts, which are developed in its southwestern part, almost entirely exclude the possibility of using the data obtained from (surface) geological surveys or shallow drilling (down to 200-500 m) for deciphering subthrust tectonics. Of all geological exploration methods, only deep drilling can be considered good for studying the subsurface structure of this zone. However, the cost of deep drilling is so high that this method, of course, cannot be applied on a wide scale. Thus it becomes necessary to apply the geophysical exploration methods and try to improve them in every respect.

Gravimetric investigations of the Carpathian foothills have given us general knowledge about the whole structure of the downwarping. Electric exploration conducted in the inner zone of the downwarping has not produced satisfactory results.

The Polish geophysicists had tried seismic exploration of this zone in 1936, but the extent of these operations was very small and they did not yield exploratory or methodical results. A systematic study of the subsurface structure of the inner zone, by seismic exploration, was began in 1950. It was conducted by crews of the West Ukranian Geophysical Office of the Trust Ukrneftegeofizika.

Until 1954 seismic exploration was undertaken mainly by the reflected wave method using continuous profiling. A part of the operations was also carried out by the correlation method of refracted waves (KMPV). A great deal of facts have been accumulated during this period. They allowed definite conclusions to be made about the exploration possibilities of this method under given seismogeological conditions. The correlation method of refracted waves did not give favorable results. As to the reflected wave method, it was found that, even though all known and available means for improving the operational efficiency of the continuous profiling procedure were used, only seldom did we succeed in accomplishing the continuous tracing of reflected waves, but in a number of instances the reflected waves were not recorded at all.

In order to find out the reasons for the poor correlation of reflections or their total absence, the author of this paper, together wih Yu. V. Timoshin, carried out a number of theoretical investigations and experimental work on models 1, 2). The results of these investigations allowed us to conclude that in the case of the non-plane reflecting interfaces there can be no continuous phase correlation in principle because of the interference formed in the area of "loops" on the hodographs. (All interfaces, the radius of curvature of which is com-

*Originally published in the "Geologiya Neft" (Petroleum Geology), vol. 2, No. 12, 1958, pages 53-59.

mensurable with the depth of their burial, can be classed as non-plane reflecting interfaces).

We cannot expect to have plane reflecting interfaces in the inner zone of the Carpathian foot hills because, from geological data, we know that all formations here had been crumpled into steep folds further complicated by small crimping and ruptures. This conclusion had a decisive effect upon the selection of a procedure of further seismic investigations to be undertaken in this zone.

In 1954, in order to study the subsurface structure of the inner zone of downwarping, the procedure proposed by the author of this paper, which later became known under the name of the three-dimensional seismic exploration undertaken on a mass scale (MPS), was applied. The very first experience in the application of the new procedure showed its principal and technical advantages, under given conditions, over the procedure of continuous profiling.

As can be seen from its name, this procedure of three-dimensional seismic exploration on a mass scale (3, 4) is based on the principle that determinations of the three-dimensional position of elementary reflecting horizons are to be made on a mass scale. The discarding of continuous profiling and transition to a new principle — the three-dimensional determination of elementary reflecting platforms undertaken on a mass scale — create a number of essential advantages in exploration.

In order to determine the three-dimensional position of an elementary reflecting platform, it is sufficient to carry out observations on two or three short (300-500 m) intersecting profiles which cover a local area of less than 0.25 km^2. This fact creates a definite advantage over continuous profiling, since even under complicated conditions, on such an area of limited size one can more often separate and trace the reflected waves.

As to the organizational techniques, the advantage of the MPS procedure consists in the fact that we can freely select the most favorable positions for shot points and geophones, which is hard to do in profiling because of the connection between the shot points and the profile line. This advantage means very much for mountain conditions, and it enables one to carry out the seismic exploration work in a location which is quite inaccessable for investigation, if made by the profiling procedure.

It is necessary that the determinations of the three-dimensional position of reflecting horizons, as required by the new procedure, be made on a mass scale. This is necessary for the applications of statistical averaging of the results and for decreasing the interpretation errors allowable in each separate case. Besides, the application on a mass scale is necessary for the detailed clarification of the complex tectonic forms of the investigated subsurface.

The results of seismic exploration undertaken by the MPS procedure have been summarized in charts of dipping vectors of reflecting horizons, in vertical seismic cross-sections, and in tectonic or structural schemes along the assumed horizons.

As to the basic defects of the MPS procedure, first of all we would mention the low accuracy in determinig azimuths and dip angles of the reflecting horizons. It can be added that the determination errors increase substantially with the decrease in dip angles. Another defect is the probability that in some instances the non-reflected waves (such as those diffracted by the facets of

faults, or refracted by steep dipping interfaces, and others) might be erroneously mistaken for reflected waves and result in an erroneous plotting of fictitious reflecting platforms. It should be noted, however, that under complicated tectonic conditions no procedural system of observations, including that of profiling, is free from this defect since under such conditions the hodographs of reflected waves do not have a hyperbolic form that would permit the distinguishing of waves reflected from plane interfaces from all other nonreflected waves.

One of the absolutely necessary conditions, when investigations are made by the MPS procedure, is that determinations be made on a mass scale. This will tend to reduce the effect of irregular errors though it cannot exclude their effect entirely. This fact should be taken into account when planning operations to be undertaken by the MPS procedure as well as when making geological interpretation of the results obtained. Experience gained in the application of the MPS procedure under Carpathian conditions allows us to think that this procedure produces rather reliable exploration results when the dip angles of reflecting horizons are not less than 10-15°.

In a relatively short period of time (from 1954 to 1956) a substantial area of the inner zone (and partially in the Skib zone) of the Carpathian foot hills has been investigated by using the MPS procedure. This area extends from Khyrov to the Striy River in the northwestern part, and from Dolina to Dub in the southeastern part of this region

In 1956, the author of this paper together with geologist V. I. Antipov compiled an overall tectonic interpretation* by using seismic exploration data obtained by the MPS procedure and by adding materials obtained earlier by continuous profiling in the region under investigation. Fig. 1 presents the northwestern part of this interpretation showing the subsurface structure of the inner zone of the Carpathian foot-hills downwarping for the areas from Khyrov, located near the state boundary with Poland, to the Striy River. The unique block character of tectonics catches the eye. Numerous transverse dislocations break up the revealed structures into more or less narrow blocks which are displaced at differing angles.

It is proper to note here that seismic exploration does not produce direct information on dislocations. In a number of instances we can conclude about their presence only from indirect symptoms. When investigations are made by the MPS procedure, the dislocation zones show up clearly on the vector chart either in the form of "white" strips, i.e., as a total absence of reflections, or in the form of an inconsistent distribution of the dipping vectors of reflecting horizons which indicates a large intermixture of formations. An indisputable sign of the presence of dislocations are the displacements of the anticlinal and synclinal axes of the folds. Such displacements are clearly observable in a number of instances and they can be seen very well in Fig. 1 on both sides of the dislocations A-A, B-B, and others. In those instances when the dislocations are not accompanied by an intermixture of formations and by displacement of structural elements in adjacent blocks, it is impossible to note them, from the seismic exploration data obtained. Also, in a number of instances, the

*This tectonic interpretation was composed from the materials obtained from seismic explorations conducted by I. Z. Gontov, I. I. Kharaz, A. P. Samoilyuk (crew chiefs), Ye. N. Stolvarova, A. I. Adamovich, L. V. Krylikova, V. I. Kulinich (interpretation engineers), M. Yu. Voitsitsky, Yu. Ya. Eichberg, and S. L. Gertsrikin (geological engineers), The managers of the field and office operations were: in geology — V. I. Antipov, the chief geologist of the West Ukrainian Geology Office — ZUGK; in geophysics — V. D. Zav'yalov, chief engineer of the West Ukrainian Geology Office — ZUGK.

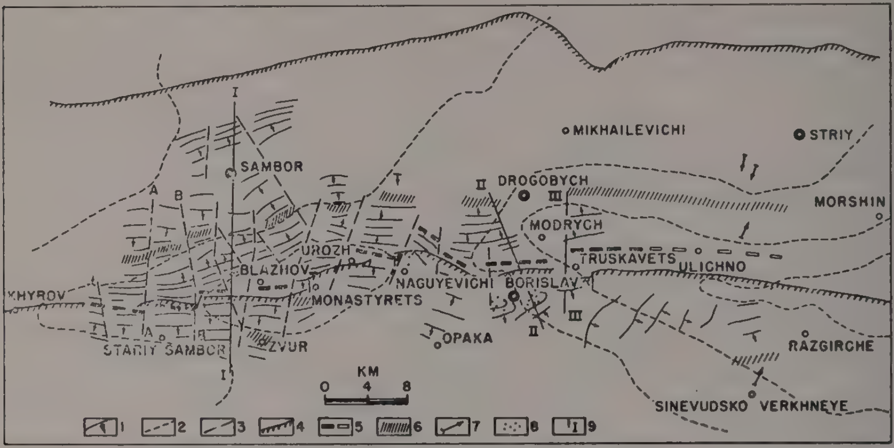

Fig. 1. Subsurface tectonics of the northwestern part of the inner zone of the Carpathian foot-hills downwarping from seismic exploration data.

1—Structure contours of the assumed seismic reflecting horizon plotted at 500 m. intervals for depths from 1500 - 4000 m.

2—gravity isoanomalies;

3—dislocations as per seismic exploration data;

4—overthrusts as per geological data;

5—axis of the subsurface anticline;

6—axis of the subsurface syncline;

7—dip direction of the reflecting horizons in sections insufficiently investigated by seismic exploration;

8—deep wells;

9—lines of the vertical seismic cross-sections (Figs. 2, 3, 4).

"white" spots on the vector chart, could be the result of some unfavorable surface conditions. Therefore, these "dislocation" zones which have been discovered only by the absence of reflections should be considered as conditional zones.

The presence in the investigated area, of a complex system of transverse dislocations which dismember the structures of folded character into a number of separate interdisplaced blocks, makes it difficult to discover the periclinal parts of the structures, and it creates serious complications when you try to single out, in the investigated area, the independent folds and solve the problem of how they are interlinked.

Another basic difficulty arises in solving the problem of the relative hypsometric position of blocks. Seismic explorations conducted by the MPS do not give such information.

Therefore, the assumed seismic horizons in different blocks or even within one block, but in different parts of it, are drawn independently and they can reflect the behavior of different stratigraphic layers.

Thus, structural constructions plotted from the seismic exploration data have but a qualitative character until they are confirmed and supplemented by proved information about the stratigraphic pecularities of the cross-section. At the present time, it is impossible to eliminate this defect by using geophysical means alone. In order to obtain a well-defined geological interpretation of

exploration data under the indicated geotectonical conditions, it is necessary to apply a complex of both seismic and drilling operations. In this complex, seismic exploration can solve the "geometric" problems, i.e. it can separate large tectonic blocks and establish the general features of the subsurface tectonics. Deep drilling guided by the data of seismic exploration should solve the stratigraphic problems, i.e. it should determine the relative hypsometric position of each block discovered by seismic exploration, and to estimate the oil-bearing prospects of these blocks.

Let us make a more detailed analysis of the tectonic scheme composed from the seismic exploration data.

The largest breaking up of formations into blocks can be observed approximately in the middle of the investigated area on a wide strip between Monastyrets and Borislav. If we compare the tectonic scheme with gravitational and geological maps we can note a conformity of the area having the largest break-up with that which has sharp variations in the extension of gravity isoanomalies and the overthrust lines. This conformity allows us to assume that the increased break-up in the indicated strip results here from the presence of a large, probably regional, fault which causes strike variations in the whole Carpathian structure. Likewise, it is not a mere accident that the oldest Borislav oil deposits are located right in this region. They became known more than 100 years ago by oil seepages to the open surface. It is also extraordinary interesting to note that the volume of oil produced here exceeds by several times the volume of reservoirs from which it had been produced (5). All these direct and indirect data lead us to the conclusion that this investigated area is rich in fractures which play a great role in its subsurface structure and which serve as conductors for oil that migrates from some large deposits not yet discovered.

The basic subsurface structures of a folded character, in the investigated area, consist of an anticlinal ridge and a wide synclinal curvature of the general Carpathian strike which had been traced within the entire investigated region. It should be particularly noted that the ridge of anticlinal structures examined below is located in the same tectonic subzone as the known Dolina deposit, and that there are absolutely good prospects as to its oil-bearing capacities.

From a joint analysis of the tectonic scheme, the chart of gravity isoanomalies, and a number of vertical seismic cross-sections, we can indicate two large subsurface anticlinal folds: the Urozh-Blazhov fold and the Truskavets fold.

It is characteristic that in the northwestern part of the area there is a wonderful agreement between the behavior of structure contours of the assumed seismic horizon and the behavior of the gravity isoanomalies of the local gravitation minimum. Isoanomalies appear to encompass the periclinal part of the Urozh-Blazhov structure closing it up in the region of Khyrov where no seismic explorations have been conducted as yet. This agreement in the behavior of isoanomalies and structure contours is hardly an accidental one. Moreover, such analogical agreement in the local gravity minima and the anticlinal structures has also been observed in other oil regions, particularly in the Apsheron Peninsula (6). As to the inner zone of the Carpathian foot-hills structure, the Dolina and Bitkov anticlinal structures also agree in their general features with the local gravity minimas. Thus we can assume that from the localization of gravity minimas, it is possible to estimate (at least in the

first approximation) the position of periclinal parts which are broken up into blocks of anticlinal structures, and, consequently, also the general dimensions of these structures. For this reason, we can assume that the linking area of the Urozh-Blazhov and Truskavets folds is located within the zone of the largest break-ups, in the region of Naguyevichi where we can observe the localization of two gravitation minima. Besides, the Urozh-Blazhov structure is 30-35 km long and 10-15 km wide.

The subsurface configuration of the Truskavets anticlinal structure, which is located in the southeastern part of the investigated area, is so far but little explored. This fold is rather clearly reflected by the vertical seismic cross-sections which cut it transverse to its strike. The most characteristic is the cross-section along the line III-III (Fig. 4.) The axis of the Truskavets fold can be traced in a northwestern direction before the Carpathian coastal overthrust between Borislav and Modrych. The interrelation of the Borislav and Truskavets structures is rather clearly reflected on the vertical seismic cross-section along the line III-III (see Fig. 4). The Borislav structure is overthrusted upon the southwestern wing of the Truskavets fold.

The general dimensions of the Truskavets structure have not been established as yet. The gravation minimum, which probably encompasses its northwestern pericline, develops in the southeastern direction and touches not only the Truskavets fold, but also the adjacent Dolina fold. Thus, in this instance, the linking area of anticlinal structures is reflected, perhaps, only by the "narrowing" isoanomalies or by the localization of minima of the third order. Judging by the seismic data at hand, the Truskavets structure is less than 15-20 km long.

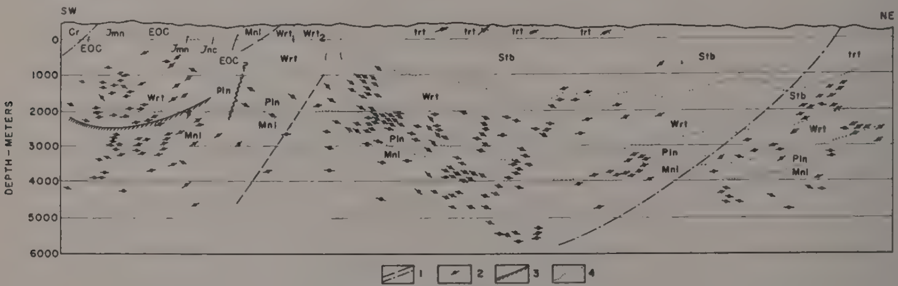

FIG. 2: Vertical seismic cross-section along line 1-1.

1—dislocations;
2—reflecting platforms;
3—assumed seismic horizon
4—stratographic boundaries.

The example, given in this paper, about the results of seismic investigations made by using the method of reflected waves and applying the procedure of the three-dimensional exploration on a mass scale, gives us a clear idea about the exploration possibilities of this new procedure. Under the extraordinary complicated geotectonic and seismogeological conditions prevailing in the inner zone of the Carpathian foot-hills curvature and of the Carpathian Skib zone where many deep exploratory wells, ordered to be drilled earlier from the data of geological survey, turned out to be unsuccessful (in the Monastyrets, Volva-Blazhev, Truskavets and other areas), and where seismic exploration operations made by the profiling procedure until 1954 were of little efficiency, the results of the seismic exploration made by the MPS pro-

cedure can be evaluated as very favorable ones. From the tectonic scheme and the vertical seismic cross-sections for the investigated territory, we can see a distinct strip of subsurface anticlinal structures which show rather high oil-bearing prospects.

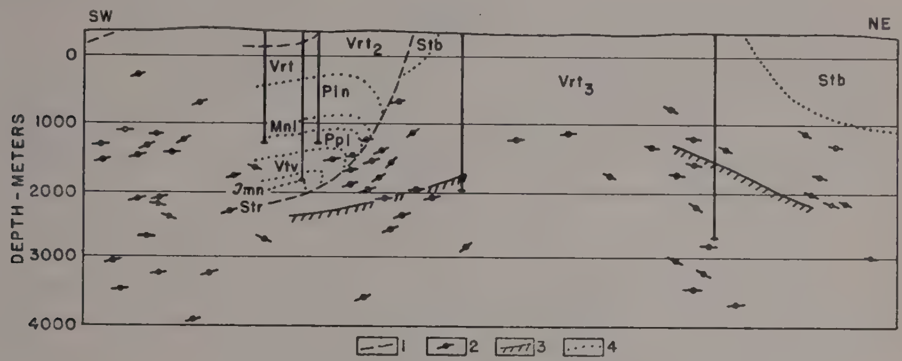

Fig. 3. Vertical seismic cross-section along the line II-II.

1—dislocations;
2—reflecting platforms;
3—assumed seismic horizon;
4—stratigraphic boundaries.

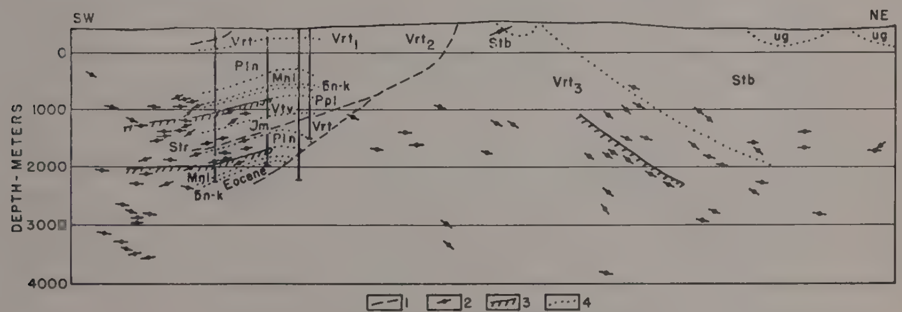

Fig. 4. Vertical seismic cross-section along the line III-III.

1—dislocations;
2—reflecting platforms;
3—assumed seismic horizon;
4—stratigraphic boundaries.

The success of seismic exploration in the inner zone of the Carpathian foot hills deserves attention for another reason. Due to the inaccessibility of the terrain, the sub-surface structure of the mountainous part of the Carpathians ranging from the Skib zone to the Cliff zone (a strip from 60 to 70 km wide) has, so far, remained almost unexplored. The geological survey of this Carpathian region reflects only the tectonics of the upper overthrusted "skib mantle" which has nothing in common with the tectonics of the subthrust formations. In the meanwhile, even the first seismic investigations of the Carpathian Skib zone allow us to assume the presence of subsurface anticlinal folds in the subthrust part of the second strip. This assumption is derived from the rising of reflecting horizons in the southwestern direction. Such rising of the subsurface horizons can be clearly observed in the southwestern part of the indicated cross-section I - I (Fig. 1.). A similar rising was noted, on the tectonic scheme, in the area of the Sinevudsko Verkhneye, and in many other places of the Carpathian Skib zone. The prospects for oil-bearing structures

buried down under the overthrusts in the mountainous part of the Carpathians might turn out not to be inferior to those of the inner zone of the Carpathian foot-hills curvature.

In addition to its direct industrial significance, investigations of the subsurface structure of the Carpathians are also of great scientific interest. Despite the fact that structural studies of the Carpathian region had already been conducted for many decades and that the geological organizations of all Near-Carpathian states have been interested in these studies, the subsurface structure of this region still remains very unclear. Such a state of affairs may be explained by the act that we have so far very little knowledge about the subsurface tectonics of the Carpathian subthrust formations.

The procedure of the three-dimensional seismic exploration made on a mass scale by using reflecting waves and a corresponding equipping of seismic crews will allow us to discover the seismic intersections of the Carpathians, and to prepare cross-sections that would explain the structure of the complex of subthrust formations down to depths of the order of 3-4 km.

These investigations can be carried out in the near future, if supported by organizations interested in them.

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STANDARD EQUIPMENT OF RADIOACTIVITY LOGGING.*

by

D. F. Bespalov and B. G. Erozolimsky

The marked success achieved in the development of radioactivity logging methods is a result of long activities performed by scientists, engineers, and scientific collectives, among others by the collectives of the laboratories of the NIIGR, the I. M. Gubkin's MNI, and the TSNIL of the Azneftegeofizika Trusts.

The decisive success in this matter was achieved in 1950-1951 by the laboratory collective of MNI under the guidance of B. B. Lapuk and G. N. Flerov. The problem of neutron-gamma-ray logging (NGK) was solved and the first models of the field equipment (RK-51) for operating the NGK and the GK were constructed.

When the NGK and the GK are operated, the intensity of the gamma-ray emission is measured. In the subsurface instrument of the equipment of station RK-51, there are three discharge counters, a cathode repeater for transmission of pulses by cable from the counters to the surface, and a stabilized high-voltage generator for feeding the counters.

The control panel, inside the instrument truck on the surface, contains the pulse amplification and formation stages, an integrator and a power rectifier for all circuits of the equipment.

The main difficulty in the production of such equipment is the need for providing a high stability for the subsurface instrument working under heavy well conditions (jolts and percussion of the instrument when moved in the well, temperatures of the surrounding medium reaching 80-100° C, high pressures of 300-400 atmospheres, etc.).

These difficulties were overcome, and station RK-51, with the MNI eqiupment, enabled wide introduction of radioactive research methods in the oil wells of the industry. The "Neftepribor" plant familiarized with the station RK-51 and produced it during 1951-1953.

The next step in fitting out the radioactivity logging equipment was the construction by the laboratory MNI in 1951-52 of a double instrument (equipment NGKK) adjusted for a simultaneous recording of NGK and GK curves.

Both collectives of the NIIGR and the TSNIL of the Azneftegeofizika Trust worked simultaneously on the construction of the RK equipment. After comparative tests had been made in 1952, the equipment NGKK made by the MNI was recommended as a model for the serial production.

The surface control panel was somewhat changed later by the NIIGR and the "Neftepribor" plant, and at the present this equipment, NGGK-53, is being put into the serial production.

The NGGK-53 equipment has important advantages as compared with the single instrument: a sharp reduction (twice or more) in time used for radioactivity logging and a full exclusion of errors, in contrasting the curves

*Originally published in Neftianoe Khoziaistvo, No. 9, 1955, pages 63-66.

NGK and GK, which are inherent in the gradual operations made by the single instrument.

In the double instrument, there are two independent systems of discharge counters located in the instrument housing.

One system consists of 6 counters of the type WS-9(1). It records the natural gamma-ray emission GK. The other system consists of 3 counters of the type MS-9(2), and it records the gamma ray emission created in the rocks by the action of neutrons (NGK). The source of neutrons remains constantly in the housing and it is placed within a 40-70 cm distance from the group of NGK counters. The system of the GK counters is placed at more than 2 meters from the source. This is a practical guarantee against any influence made by the source upon the GK effect.

As in the 1951 model, the double equipment, NGGK-53, consists both of a subsurface instrument and a surface control panel set up in the instrument truck, AKSL-51.

The block-diagram of this equipment is shown in Fig. 1, but its diagram is illustrated in Figures 2 and 3.

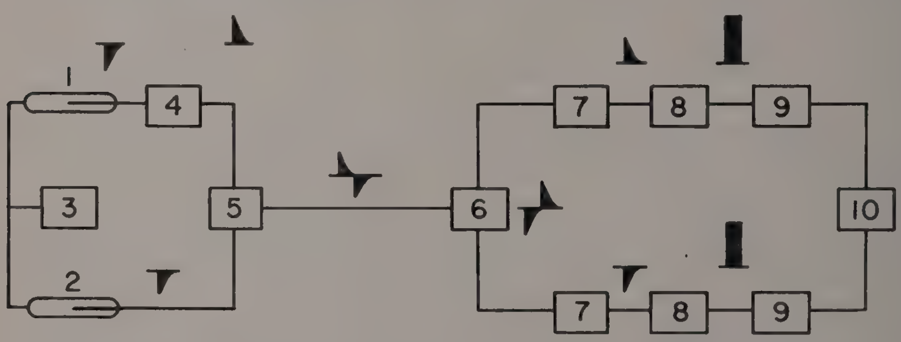

FIGURE 1. Block-diagram of the double equipment for radioactivity logging NGGK-53.

1–GK counters (6 pieces)
2–NGK counters (3 pieces)
3–stabilized high-tension generator
4–reversing stage of GK pulses
5–mixing stage
6–amplifying stage
7–separating stage
8–standardizing stage
9–integrator
10–self-recorder (photo recorder).

(see Fig. 2)

Pulses from the GK and NGK counters enter the mixing stage which consists of two cathode repeaters (tubes T_1 and T_7) with a common cathode loading. Besides, the GK counter pulses first pass through the stage No. 4 (tube T_2) which reverses the pulse sign.

Thus pulses from both counter systems enter the cable, but they are of reversed polarity (GK pulses are positive and NGK pulses are negative).

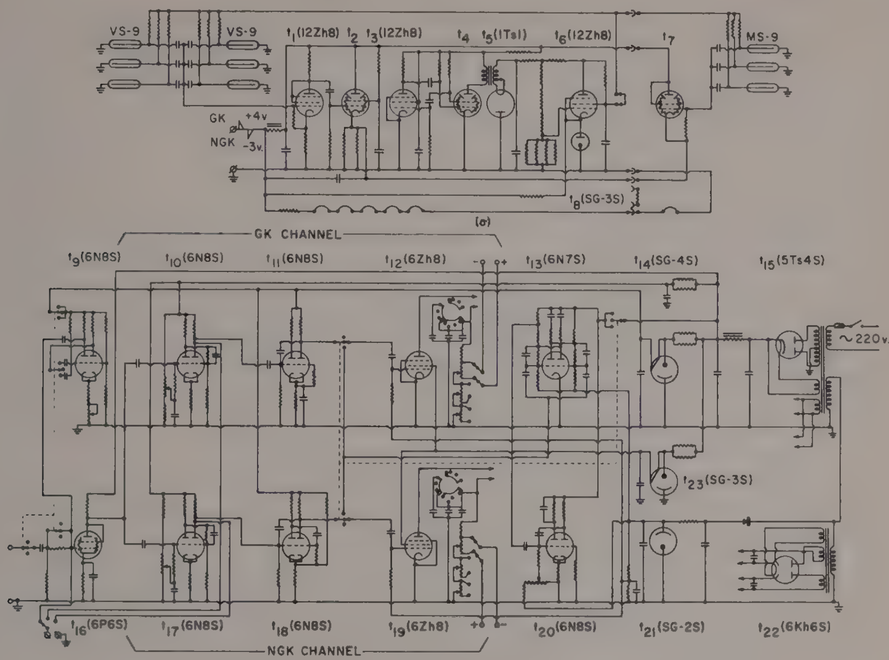

FIGURE 2. Principal Diagram of the Equipment NGGK-53.

a. Subsurface instrument. b. Surface panel.

On the earth's surface, pulses are amplified by the tube T_{16} (6). In addition they change their sign. Then they are transmitted into stages No. 7 (tubes T_{10} and T_{17} which separate pulses of a definite polarity. One of these stages (tube T_{10}) lets through only the negative GK pulses, and the other one only the positive NGK pulses.

After this separation the GK and NGK pulses are standardized according to their duration and amplitude. The standardizing stages consist of two identical fixed period multivibrators (8) consisting of tubes T_{11} and T_{18}.

The standardized pulses then enter the input of the integrating stages (9), consisting of tubes T_{12} and T_{19}, which are pentodes with resistance-capacitance integrating circuits connected in the anode circuit. The magnitude of the integrating circuit constant time is determined by using switches depending on the character of the work (logging speed, source power, geological cross section).

The voltage coming from the outputs of both integrators is proportional to the number of pulses recorded by the corresponding system of counters within a unit time. This voltage is passed on to the galvanometers of the photo recorder FR-3/4 (10).

Thus, while the subsurface instrument traverses the well bore, the two curves of the GK and NGK are simultaneously recorded on the recorder's photo paper.

The high voltage (about 1,000 volts) used for feeding the discharge

counters is produced by a special generator (3) placed within the subsurface instrument itself. The generator uses two tubes T_3 and T_4 in accordance with the scheme of a free-running multivibrator with a high-voltage transformer connected with the anode of the power tube T_4. The high tension is stabilized by the parallel-type electronic regulator (tubes T_6 and T_5). This scheme was developed in 1950 for the RK-51 instrument. It showed high-quality performance during three years of operations and was incorporated into the NGGK-53 equipment.

This equipment is planned to operate with a "single-core" armored cable. The voltage for feeding the tubes of the subsurface instrument is passed through the same conductor by which the pulses return, and it is separated from them by means of filters. The rectifier of the AKSL-51 station serves as a supply source for the instrument. The feeding of stages in the surface equipment is made from the self-contained rectifier in the panel. The anode voltage of the standardizing and integrating stages is stabilized by means of gas stabilizers (tubes T_{14}, T_{21} and T_{23}).

To insure the possibility of direct counting of the number of pulses in the channels GK and NGK, a recounting device is provided in the control panel with an output multivibrator consisting of tubes T_{13} and T_{20}. This device operates an electro-mechanical pulse counter. This circuit may be switched to either of the channels. To check on the working of the surface panel and for calibration of the recording network there is a calibrator consisting of a free-running multivibrator (tube T_9).

The subsurface instrument is enclosed in a protective steel housing. This housing is about 4 meters long and has a diameter of 102 mm. In the lower part of the housing there is the chamber containing the neutron source which is necessary for the NGK.

Tests have shown that the described equipment possesses good operating qualities. During long, continuous work (from 15 to 20 hours), the readings of the instrument have remained stable and they have repeated correctly to 1.5-2%. Changes in the circuit voltage of ± 10% have practically no effect on the instrument's work. The working stability has not been impaired by wide changes of temperature in the surrounding medium. Thus, when the discharge counters have been properly selected (or special thermo-resistant counters have been used), the instrument has worked normally at temperatures as high as 100° C.

For the present, the double instrument, NGGK-53, is the main instrument for radioactivity logging of bore holes.

In our opinion, a further development of this equipment may be conducted toward the improvement of the scheme of the pulse-distribution according to their polarity, toward the increase of the subsurface instrument's working temperature to 130-150° C, and toward the increase in the sensitivity of the emitted gamma-ray counters in order to increase the logging speed and the precision of measurements.

ABSTRACTS OF PAPERS AND LECTURES GIVEN BEFORE THE GEOPHYSICAL SOCIETY OF TULSA 1958-59

1. Survival Factors In Oil Exploration

PAUL L. LYONS, Sinclair Oil and Gas Co.
October 8, 1958

2. Seismic Noise

M. R. MacPHAIL, Humble Oil and Refining Co.
November 13, 1958

Abstract

Seismic noise, as defined for this discussion, denotes the incoherent part of a seismogram, that is, the part that persistently fails to "carry" across a spread of conventional length. In areas regarded as seismically difficult, the coherence, or more precisely the correlation coefficient between pairs of traces, generally appeared to decrease monotonically to zero with increasing separation between pickups, the rate of decrease varying from area to area. In areas where reflections were fairly evident the coherence leveled off at a certain positive value determined by the strength of the reflections.

The seismic noise from quite a large number of localities studied appeared to be random resulting from the superposition of many events. Randomness in arrival times could result from either a random distribution of sources in the earth, or variation in seismic velocity from point to point, or both. Noise is seismic energy scattered by many small, randomly distributed inhomogenities. Calculations based on this premise lead to a coherence–distance relation that is qualitatively similar to those observed. By means of the coherence-distance relation for a particular area, it is possible to specify a pickup pattern that will effectively increase the ratio of coherent to incoherent energy. Examples will be given and discussion invited.

3. Evaluation, Handling and Storage of Magnetic Tape

ROBERT B. FISHER, Davis Equipment Co.
December 11, 1958

Abstract

Although many technical papers have been prepared covering the theory and operation of magnetic recording equipment as a useful method of storing and processing geophysical field data, information regarding the recording media or the tape itself has heretofore been discussed only briefly.

A brief historical background of magnetic recording and an explanation of magnetic theory and terminology is given. The characteristics of magnetic oxides and backing materials in common use in the geophysical industry are presented. The effects on recorded signals of pinholes, nodules, and other tape defects are analyzed. The proper methods of handling, shipping, and storing of magnetic recording materials are explained.

4. The Dependence of Seismic Form and Frequency Content on Shot Variables

R. N. JOLLY and V. R. JOHNSON, Jersey Production Research Co.

January 8, 1959

Abstract

Detailed field experiments were performed to determine how charge size, depth, and length affect seismic pulse form and frequency content. Downward and upward traveling pulses were observed at distances ranging up to 400 feet from the shot, and reflection records were recorded simultaneously. A cemented vertical array of geophones was used to provide undistorted recording of subsurface waveforms.

Downward-traveling pulse form proved to be sensitive to all three variables. Increased charge size and length usually resulted in pulse broadening. Major changes in pulse structure, however, are related to shot depth. These changes are apparently caused not so much by variations in the medium surrounding the shot as by layer geometry which affects the phase relationships of pulses reflected downward from layers above the shot. In contrast to downward-traveling pulses, uphole waveforms were found to broaden greatly with increasing charge size. Fourier analysis of all down-traveling pulses were made to permit direct examination of that part of the spectrum lying in the reflection band of frequencies. These analyses show relatively minor changes in shape of the spectral curves in this region as charge size and length were varied. Charge depth variations, on the other hand, cause spectral nulls or inflections which can be correlated with character changes on reflection records. Other supplemental topics, such as ultrashallow reflection recording on the array of subsurface cemented geophones, are discussed briefly.

5. Geophysics and Stratigraphic Problems

GERALD H. WESTBY, Seismograph Service Corp. AAPG Distinguished Lecturer

January 19, 1959

(Joint Meeting with Tulsa Geological Society)

Abstract

The exploratory branch of the oil industry has engaged in massive research, attempting to develop suitable means of exploration in anticipation that this country will be dependent on stratigraphic traps for most of its future oil and gas.

A report is given on the various methods and techniques which have been developed by the industry to assist in solving this exploratory problem. The necessity of cooperation between all branches of earth science in improving and intensifying the search for oil entrapped under these conditions is emphasized.

6. Discussion of a Visit to Russia

T. A. MANHART, Century Geophysical Corp.

February 12, 1959

Mr. Manhart discussed his recent visit to Russia. Films and slides were shown to highlight interesting phases of his talk.

7. A Survey of Soviet Geophysical Literature

J. J. ROARK, Jersey Production Research Co.
March 12, 1959

Abstract

The average geophysicist is generally unaware of the large amount of Soviet geophysical literature which is available and has been for many years. This includes both periodicals and books. The technical quality of the periodical articles is generally fair-to-good. However, the presentation of the material usually differs from that of the corresponding American literature.

In order to compare the Soviet literature with the corresponding American literature, all articles from two Soviet and three American journals are classified as to subject and type of article.

(Complete article is in GEOPHYSICS v. 24, No. 5: 910-915; Dec. 1959)

8. Some Natural Phenomenon as Applied to Oil Finding

H. M. THRALLS, GeoProspectors, Inc.
March 12, 1959

Abstract

All geophysical methods are dependent upon the measurement of variations of some phase of transmitted energy or induced energy, or alterations of earth properties caused by the presence of materials sought. The author suggests a measurement of secondary effects as an indirect method of measuring a geophysical property.

9. Ghost Elimination From Reflection Records

J. W. HAMMOND, Seismograph Service Corp.
April 9, 1959

10. Some Results of the IGY

J. A. WESTPAHL, Sinclair Research Laboratories
April 9, 1959

11. Airborne Gravity Measurements In a KC-135 Jet Airplane

LUCIEN LaCOSTE, LaCoste and Romberg
May 14, 1959

Abstract

Last November successful gravity measurements were made in a KC-135 jet airplane at Edwards Air Force Base, California. The gravity meter used was a LaCoste and Romberg Surface Ship Gravity Meter. Dr. Lloyd Thompson of the Cambridge Air Force Research Center arranged for the test and for the navigation. The navigation consisted of doppler radar and very accurate phototheodolites mounted on the ground. Gravity readings were obtained on six runs. The readings were consistent with each other and with the gravity value on the ground. A run over mountains showed an anomaly, and a north run showed latitude variation. An accuracy of about 10 mgls is indicated.

12. Techniques for Improving Seismic Interpretation

R. W. MOSSMAN and R. S. FINN, Seismograph Service Corp.
May 14, 1959

ABSTRACTS OF PAPERS AND LECTURES GIVEN BEFORE OTHER LOCAL GEOPHYSICAL SOCIETIES

1958-1959

ARK-LA-TEX GEOPHYSICAL SOCIETY

Shreveport, Louisiana

(Chartered March 12, 1949)

A more complete and accurate interpretation of seismic data can be obtained through use of modern recording, display, and analysis techniques. These new methods provide greater stratigraphic and structural information and better evaluation of unwanted energy arrivals. Examples are given, showing improvements obtained by application of such methods.

13. Resolution of Anomalous Masses

E. V. McCOLLUM, E. V. McCollum and Co.

September 22, 1958

Abstract

Anomalous mass may be estimated by computing the flux of gravity through the earth's surface. When the calculations are made at a number of points on the earth's surface, the values may be placed on a map and contoured. The resulting picture tends to resolve local gravity anomalies and subdue regional effects. In favorable situations the causative mass may be approximated. In less favorable cases the anomalous mass aids in placing depth ranges on the disturbing mass.

14. Ghost Elimination from Reflection Records

J. W. HAMMOND, Seismograph Service Corp.

October 27, 1958

15. The Removal of Water Reverberations Through Modern Data Processing Techniques

MILO M. BACKUS, Geophysical Service Inc.

November 24, 1958

Abstract

(Complete article in GEOPHYSICS v.24, No. 2: 233-261; April 1959)

In offshore shooting the validity of previously recorded seismic data has been severely limited by multiple reflections within the water layer. The magnitude of this problem is dependent on the thickness and the nature of the boundaries of the water layer.

The effect of the water layer is treated as a linear filtering mechanism, and it is suggested that most apparent water reverberation records probably contain some approximate subsurface structural information, even in their present form.

The use of inverse filtering techniques for the removal or attenuation of the water reverberation effect is discussed. Examples show the application of the technique to conventional magnetically recorded offshore data. It has been found that the effectiveness of the method is strongly dependent on the instrumental parameters used in the recording of the original data.

16. A Practical Interpretational Approach to Seismic Record Sections

C. N. PAGE, Continental Geophysical Co.
January 26, 1959

Abstract

The suggestion is made that reversed prints made on opaque paper could be worked on the backs when placed over a light table. When the lights are turned off the resulting picks can be seen but the traces cannot. The effect is similar to a conventional plotted cross-section.

17. Geology and Geophysics of Alaska

JOHN R. WOOLSON, United Geophysical Co.
February 11, 1959

Abstract

Northern Alaska is separated from the remainder of the 49th state by the Brooks Mountain Range. It is the approximate northern one-third of the state and an area of about 70,000 square miles with which this paper is concerned. It is divided into two administrative units with about 37,000 square miles in the Naval Petroleum Reserve No. 4 and 33,000 square miles under the Bureau of Public Lands.

Structurally, the area is a single asymmetric basin similar in general structural aspect to the Denver-Julesberg basin and the Alberta Basin. The principal sedimentary rocks of the basin are Cretaceous which thicken from about 2,000 feet in the north to 20,000 feet or more in the south. Lithologically, the Cretaceous consists of a shallow sand-shale sequence about 3,000 feet thick (the upper Cretaceous) and an underlying shale (the lower Cretaceous) which thickens from north to south. The Brooks range is a complex of thrust faults and related folds in the pre-Cretaceous. The effect of this thrusting is a series of elongate east-west trending diapir folds in the Cretaceous which extended about 100 miles north of the mountain front.

As a result of the Navy's exploration program, oil and/or gas was discovered at Barrow, Simpson, Umiat, Gubik and Fish Creek. None of these wells developed commercial quantities of oil but they do indicate the area is a potential petroleum province.

The principal objective horizon would seem to be the Mississippian-Lisburne limestone which is about 2,000 feet thick in outcrop and has some outcrop seeps and a petroliferous odor in fresh fracture. It was missing in the test wells drilled in the northern part of the area near Point Barrow. It should occur in major thrust folds near the mountain front, such a fold is interpreted at Carbon Creek anticline, a surface structure which can be followtd fcr about 100 miles in an east-west direction. The Lisburne was not drilled into during the course of the 1945 to 1953 exploration program.

Seismic results in the area were generally good and checked both the drilling and surface geology after being corrected for velocity variation. Gravity results seem to be useful to define structure in the higher density pre-Cretaceous. There is, for example, a gravity definition of the Carbon Creek thrust fold and a pre-Cretaceous cryptovolcanic structure near Point Barrow. The airborne magnetometer results do not seem to be useful to define structure in the sedimentary section.

Operation and support problems are, of course, complicated by remote-

ness and an inhospitable climate. These problems have been solved and costs were not materially different from any other "foreign" area. Although an extensive exploration program was conducted; it was quite limited relative to the size of the area. It would seem that the exploration program reached the stage of knowing what needed doing.

18. The Synthesis of Seismograms from the Continuous Velocity Log

ASOCIACION VENEZUELA de GEOFISICA
Caracas, Venezuela

R. L. GARDUNO, Seismograph Service Corp of Venezuela and

E. J. ASSITER, Socony Mobil Oil Co. of Venezuela

September 30, 1958

Abstract

The simulated reflection seismograms now available as a by-product of the Continuous Velocity Log are playing an important role in the field of seismic exploration. The simple but realistic analogy upon which the simulated seismograms are made has an immediate and fundamental application when used to advance the basic concepts on seismic reflections. It has served to clarify ideas originating from the long retained but misleading assumptions. The analogy is illustrated by the elementary form of a "Hand Made Synthetic Seismogram" for which some practical applications are given. A general discussion on the analog computor, and electronic data processing methods, presently used for industrial processing of synthetic seismograms is made. Examples are presented on some applications of this tool as an aid in structural and stratigraphic seismic prospecting.

19. A Paper on Aerial Magnetics

NELSON STEENLAND

October 24, 1958

20. Estudios Seismologicos sobre Temblores de Tierra

DOCTOR GUNTHER FIEULER, Institute Seismologico del Observatorio Cagigal

December 2, 1958

21 Geological Application of the Continuous Velocity Log

H. L. BRYANT, Creole Petroleum Corp.

February 2, 1959

Abstract

Creole completed a preliminary evaluation of Continuous Velocity Logs in 1955. The results of this study led to further work which developed definite geological and well logging applications for this relatively new tool. From the geological standpoint Creole has found that the Continuous Velocity Log may be useful in 1.) difficult correlation work 2.) location of gas zones, gas/oil contacts and oil/water contacts in high porosity zones. 3.)determining porosity in sandstones and limestones. 4.) lithology studies including sand/shale ratios, sand/carbonate ratios, regional isoporosity maps and 5.) location of fracture zones. Illustrations are presented to demonstrate the many useful applications of Continuous Velocity Logging.

22. Applications of the Sonic Log

C. A. DOH, Schlumberger Surenco
March 2, 1959

Abstract

The principles and field operations of sonic logging are described and the following applications discussed:

Geological applications to correlations, determination of porosity, detection of fractures, detection of gas, location of oil-water contact, location of fault zones, location of coal or lignite beds, and the use of the integrator for determining average porosity over the producing section. Its application to the interpretation of seismic surveys and comparisons of sonic velocities versus check shot are reviewed.

23. Resume on Continental Drift

GEORGE W. TRUMP, Creole Petroleum Corp.
May 18, 1959
(Joint meeting with Association Venezolana De Geologia, Minera Y Petroleo)

Abstract

The problem of the distribution of continents and oceans is by no means solved. Geological opinion is still divided. Gondwanaland geologists (S America, Africa, India) are favorably inclined toward continental drift, as are many Chinese and Japanese researchers. European thought seems to be both pro and con while in North America, the theory finds few if any champions.

According to recent publications on paleomagnetics some form of continental or polar displacement is indicated and Adrian Scheidegger's work in geodynamics leads him to the conclusion that of all the current theories regarding the origin of continents and ocean basins, Continental Drift may well be the most acceptable. This theory will be reviewed as set forth in 1924 by A. Wegener, and modified later by A. duToit, B. Gutenberg and others.

24. Latest Positioning Techniques for Airborne Geophysical Surveys

T. OFTELI, Aero Service
June 23, 1959

25. The Airborne Magnetometer

by U.S.C.A.
June 23, 1959
(Joint meeting with Asociacion Venezolana De Geologia, Minera Y Petroleo)

CANADIAN SOCIETY OF EXPLORATION GEOPHYSICISTS

Calgary, Alberta, Canada
(Chartered January 24, 1952)

26. Experimental Studies of the Magneto—Telluric Method of Exploration

C. D. GARLAND, University of Alberta
January 23, 1959

27. Review of Geophysics

E. V. McCOLLUM, E. V. McCollum and Co.
February 19, 1959

CASPER GEOPHYSICAL SOCIETY
Casper, Wyoming
(Chartered May 23, 1953)

28. Resolution of Anomalous Masses

E. V. McCOLLUM
September 9, 1958

(See No. 13)

29. Geophysics and Stratigraphic Problems

G. H. WESTBY
September 24, 1958
(Joint meeting with Wyoming Geological Association)

(See No. 5)

30. Generation of Seismic Waves by Weight Drop

S. N. DOMENICO, Pan-American Petroleum Corp.
October 9, 1958

Abstract

A series of experiments designed to evaluate the weight-drop technique was conducted in West Texas. These tests demonstrated the general nature of the seismic waves generated by a weight drop and the effectiveness of compositing drops in providing useful reflection information.

At the first of two test sites discrete waves from single drops consisted of a refracted wave, an air-earth coupled wave, reflected wave segments, and fragmentary waves which were likely dispersive surface waves. A 72-seismometer array provided appreciably more reflected wave segments on records from single drops and also on records from the composite of these drops than did a single seismometer. Additional testing revealed that records prepared from weight drops along three parallel lines 100 ft. apart recorded at the same seismometer station are appreciably different. Compositing of the drop lines in general did not provide reflections superior to the best on individual lines.

At the second test site record quality appeared significantly superior to that at the first site. Discrete waves on records from single drops recorded by a 36-seismometer array were of the same types as those observed previously. However, the air-earth coupled wave, prominently developed at the first site, did not appear. Compositing of drops provided two prominent reflections which were correlatable over a 5-mile traverse.

(Complete article in GEOPHYSICS v. 23, No. 4: 665-683; Oct. 1958)

31. Velocity Log Characteristics

A. A. STRIPLING, Magnolia Petroleum Co.
November 10, 1958

32. Cross Section Display From Magnetic Tapes

ROBERT S. FINN, Seismographic Service Corp.
December 1, 1958

Abstract

The use of magnetic recording makes possible various methods of handling field seismic data, which can improve interpretability of the data and which

are not practical with conventional recording. Also data can be displayed in various forms which can make interpretation easier, more accurate, and more complete. These display forms usually consist of corrected record cross-sections made with conventional galvanometer traces, variable area traces, or variable density traces. This paper will discuss a specific magnetic replay system and its cross-section presentations, with examples of the results.

33. The Evaluation, Handling and Storage of Magnetic Tapes

ROBERT B. FISHER
January 6, 1959

(See No. 3)

34. Corrections of Seismic Time Maps for Lateral Variation In Velocity Beneath the Low Velocity Layer

C. H. ACHESON, Imperial Oil Ltd.
February 4, 1959

Abstract

Lateral variation in velocity beneath the low velocity layer often causes time anomalies that obscure the true structural picture. A method of correction to a deep datum has been developed to minimize the spurious anomalies without affecting those caused by structure. This method makes use of the discovery that for any particular well in Western Canada, there exists a simple expotential relationship between time and depth so that the results of relatively shallow core hole velocity surveys can often be extrapolated to predict times to much greater depths. An example is given to show how this method was applied successfully to a particular problem area in Western Canada. It has since been used in several other places.

(Complete article in GEOPHYSICS v. 24, No. 4; 706-724; Oct. 1959)

35. Mississippian in the Alberta Plains and the Reflection Seismograph

G. J. BLUNDUN, Home Oil Co., Ltd.
March 5, 1959

Abstract

The eroded Mississippian surface is the major unconformity in the province of Alberta. To map its erosional high and lows is most important, because the Mississippian may be productive of hydrocarbons or may cloak the attitude of deeper sediments from which production is sought. This paper deals with the methods of presentation of reflection seismic data to that end, together with a suggested recording instrument technique. Some of the interpretive problems, and the possible significance of Mississippian porosity on the acoustic impedance of its reflection are mentioned.

Maps of similar data, one geological and the other reflection seismic, are presented for comparison. The former is obtained from drilled wells and the latter from reflection shooting performed prior to drilling.

(Complete article in GEOPHYSICS v. 24, No. 3; 426-442; July 1959)

36. Well Logs and Magnetic Tape

J. P. WOODS, The Atlantic Refining Co.

April 16, 1959

Abstract

Well logs can easily be recorded on magnetic tape. Present logs can be transcribed on to tape, or the logs can be written on tape at the wellsite. Twenty or more curves can be written on a single tape, and each curve can have an amplitude range as great as one hundred. Once recorded on tape, logs can be played back to various scales and amplitudes. The log of an inclined hole can be corrected to vertical. A log recorded in depth can be played back in seismic time. A log can be filtered to produce a synthetic seismogram. Logs can be filtered to aid in the correlation process. Finally, logs on tape can be fed into computing machines which make correlations by a mathematical process.

37. Geophysical Case History of the Horse Creek Field, Laramie County, Wyoming

J. W. PETERS, Mobil Producing Co.

May 4, 1959

COASTAL BEND GEOPHYSICAL SOCIETY

Corpus Christi, Texas

38. Resolution of Anomalous Masses

E. V. McCOLLUM

April 14, 1959

(See No. 13)

39. Velocity Log, an Industry Tool

HUGH HARDY, Humble Oil and Refining Co.

May 12, 1959

COCHABAMBA GEOPHYSICAL SOCIETY

Cochabamba, Bolivia

40. Resume of Seismic Techniques and Results in Bolivia

J. R. HEGBLOM, Bolivian Gulf Oil Company

December, 1958

Abstract

Shooting and recording techniques used by the private oil companies and their contractors in Bolivia are described. Typical records are shown as obtained by varying spread lengths, amounts of dynamite, deep holes, patterns and filter settings. Number of personnel and costs are briefly discussed. Conclusions are drawn concerning typical techniques used in various parts of the Chaco Basin.

DALLAS GEOPHYSICAL SOCIETY
Dallas, Texas
(Chartered August 7, 1948)

41. A Method of Obtaining Seismic Data Using Well Logs and Seismograms

STUART C. MUT, and C. W. FRICK, The Atlantic Refining Co.
September 8, 1958

Abstract

There are several areas in which insufficient average velocity control hampers seismic exploration. In some areas, neutron logs and resistivity logs display a good correlation with the continuous velocity log. Synthetic seismograms completed from the neutron or resistivity log, in many cases, make possible the precise identification of one or more events recorded on a seismic record shot near the well. The time of the event is taken from the seismic record, the depth from the well log. After certain corrections are applied, the average velocity is calculated. The evidence suggests that one-way time-to-depth determinations good to ± 10 milliseconds are obtained in many cases.

42. Qualitative Analysis of Multiple Reflections

W. S. HAWES, Seismic Explorations, Inc.
October 6, 1958

Abstract

Seismic records from Southern Alabama exhibiting strong multiple reflections are presented together with auxiliary data designed to yield a qualitative analysis of the specific case. In conjunction, several aspects of the general problem of multiple reflections are considered: surface and subsurface factors conducive to propagation of high level multiples, the compounding effect of two or more strong reflectors, and suggested methods for qualitative prediction and detection of multiples.

43. Geophysics and Stratigraphic Problems

G. H. WESTBY
October 29, 1958
(Joint meeting with Dallas Geological Society)

(See No. 5)

44. Elimination of Water Reverberations Through Modern Data Processing Techniques

MILO M. BACHUS,Geophysical Service Inc.
November 10, 1958

(See No. 15)

45. Study of Guided Crustal Waves

EUGENE HERRIN, Southern Methodist University
December 8, 1958

46. The Dependence of Seismic Pulse Form and Frequency Content on Shot Variables

V. R. JOHNSON, Jersey Production Research Co.
January 12, 1959

(See No. 4)

47. Nature and Growth of Louisiana Salt Domes and Its Effect on Oil Accumulation

GORDON I. ATWATER
February 9, 1959
(Joint meeting with Dallas Geological Society)

48. Economics and Exploration

JOHN J. ARPS, British American Oil Producing Co.
April 9, 1959
(Joint meeting with Dallas Geological Society)

49. Expeditions to the Antarctic

DANIEL LINEHAN, S. J., Boston College
May 8, 1959
(Joint meeting with Dallas Geological Society)

50. Two Months in 1958 Visiting Geophysicists and Geologists in (the) USSR and China

J. TUZO WILSON
May 18, 1959

DENVER GEOPHYSICAL SOCIETY
Denver, Colorado
(Chartered May 19, 1950)

FORT WORTH GEOPHYSICAL SOCIETY
Fort Worth, Texas
(Chartered August 7, 1948)

51. The Perils of the Market Place

ROBERT P. DUPREE, Wm. N. Edwards and Co.
June 30, 1958

Abstract

Sound advice for small investors was given along with warnings about certain pitfalls which often catch unwary speculators. Sound advice was made interesting by the insertion of humorous illustrations.

52. Shut the Damn Thing off

WALTER R. MITCHELL, National Geophysical Co.
August 25, 1958

Abstract

A demonstration of high fidelity reproduction from tapes and records, both monaural and stereophonic was the high light of this very interesting talk about his hobby.

53. The Revolution in Petroleum Exploration

O. C. CLIFFORD, The Atlantic Refining Co.
September 30, 1958

Abstract

This was an abridged version of Mr. Clifford's Presidential Address which was presented to the Annual Meeting in San Antonio. Mr. Clifford presented

a rather critical picture of the status of Petroleum Exploration and suggested some adjustments which would have to be made to live with the situation.

54. Seismic Prospecting—Facts, Fantasies and Economics

HUGH M. THRALLS, GeoProspectors, Inc.
October 27, 1958

Abstract

Mr. Thralls presented an optimistic picture of the future of seismic exploration but stated that the use of the seismic tool would henceforth be much more selective than in the past and that the geological interpretation of the geophysical data must receive more and more attention.

55. The Applications of Electronic Computers and Data Processing Equipment to Exploration

W. S. PICKRELL, International Business Machine Co.
November 24, 1958

56. A Producer's Look at Gas As An Influence On Exploration and Production Operations

ROY T. DURST, Richardson and Bass
January 26, 1959

Abstract

This paper reviews the recent trends in the discoveries of United States and World petroleum reserves and the relative rates of domestic consumption of both oil and gas. The downward trend in oil allowables and the increasing demand for natural gas have resulted in the search for gas alone where assured field prices are increasing. At the present time, Mississippi and Southern Louisiana have economic advantages over South and East Texas and the West Texas-New Mexico area. Applications for Certificates of Public Convenience and Necessity have been filed with the Federal Power Commission covering more favorable prices in the Permian Basin area of West Texas-New Mexico, and the Texas Panhandle. If these applications are approved and if permanent certificates are granted, natural gas in those areas will take on greater importance than in the past.

57. Profitability Calculations In The Petroleum Industry

JOHN J. ARPS, British American Oil Producing Co.
February 10, 1959

Abstract

Economics of all facets of petroleum from exploration costs to the evaluation of oil fields has become increasingly more important. "Economic" data can be prepared and presented in many different ways.

58. A Proctical Interpretational Approach to Seismic Record Sections

C. NEWTON PAGE, Continental Geophysical Co.
March 23, 1959

(See No. 16)

59. A Legal View of the Privileges and Perils of Prospecting

EDGAR H. KELTNER
April 23, 1959

Abstract

This talk covers recent decisions on ligitation in Texas which will have increasing bearing on geophysical operations in the State.

FOUR CORNERS GEOPHYSICAL SOCIETY
Durango, Colorado

60. The Revolution in Petroleum Exploration

O. C. CLIFFORD, JR.
September 19, 1958

(See No. 53)

61. Effects of Changing Stratum Thickness on Reflection Seismographs

R. A. PETERSON, United Geophysical Corp.
October 10, 1958

62. Geophysics and Stratigraphic Problems

G. H. WESTBY
November 7, 1958
(Joint meeting with 4 Corners Geological Society)

(See No. 5)

63. Resolutions of Mass Anomalies

E. V. McCOLLUM
December 5, 1958

(See No. 13)

64. Every Day Tensions and Heart Disease

MENARD MURRAY, M.D.
January 16, 1959

65. Geophysics in the Four Corners Area

W. J. OSTERHOUDT
February 22, 1959

66. The Future of American Petroleum Geology

FRANK B. CONSELMAN
March 13, 1959

67. Oil Potential of the Niobrara Shale in Southern Wyoming and Northern Colorado

E. R. McAUSLAN
April 17, 1959

68. Shooting Depths and Media

W. J. OSTERHOUDT, Consulting Geophysicist
May 23, 1959

69. Instrumentation

T. O. HALL, General Geophysical Co.
May 23, 1959

70. Multiples

W. S. HAWES
May 23, 1959

(See No. 42)

GEOPHYSICAL SOCIETY OF EDMONTON

Edmonton, Alberta, Canada
(Chartered February, 1958)

71. Oil Occurrence in Salt Basins

PAUL M. TUCKER,The Carter Oil Co.
October 6, 1958

72. Current Research of the Upper Atmosphere, Ionosphere and Aurora

C. T. ELVEY
December 15, 1958

73. Determination of Crustal Thicknesses and Velocities in Alberta by Seismic Refraction Techniques

T. C. RICHARDS, Triad Oil Co., Ltd.
January 30, 1959

Abstract

Following seismic observations in the Albertan Plains from the Ripple Rock explosion, a refraction line some 81 miles long and parallel to the frontal thrust of the Rocky Mountains and about 60 miles to the east thereof was observed by two-way shooting.

Fifteen seismic parties, spaced at roughly uniform intervals along the line and using the method of close geophone correlation, were employed, the object being to map as many refractors or reflectors as possible as far as the Mohorovicic discontinuity. The results indicate that this discontinuity occurs at a minimum depth of 43 km where the velocity is about 8.2 km/sec, while an intermediate layer with a minimum depth of 29 km and velocity 7.2 km/sec has been registered. Other intermediate refractors were observed. These results are compared with those obtaining in other parts of the American continent and elsewhere.

The operational, instrumental, and theoretical aspects of the work are discussed.

(Complete article in GEOPHYSICS v. 24, No. 2; 262-284; April 1959)

74. A Review of Geophysics

E. V. McCOLLUM, E. V. McCollum and Co.
February 17, 1959

75. Informal Discussion on the S.E.G.

W. M. ERDAHL, Skelly Oil Co.
February 17, 1959

76. Correction of Seismic Time Maps for Lateral Variation in Velocity Beneath the Low Velocity Layer

C. H. ACHESON, Imperial Oil Ltd.
March 24, 1959

(See No. 34)

77. Synthetic Seismograms

LEONARD J. LARGUIER, Geophysical Consultant
April 10, 1959

Abstract

Interpretation of pinchout and stratigraphic changes from seismic records has always been desired. Now, better and more detailed knowledge of seismic velocities resulting from continuous velocity logs make possible better understanding of the elements of the traces on a seismic record. Construction and study of synthetic seismograms, made either from continuous velocity logs or from electric logs, now lead to the possibility of pinchout and stratigraphic interpretation as well as to the improvement of conventional structural interpretation.

78. Recent Expeditions to the Antarctic

DANIEL LINEHAN, S. J., Boston College
May 20, 1959

GEOPHYSICAL SOCIETY OF HOUSTON

Houston, Texas
(Chartered February 14, 1948)

79. So Now You Have it on Tape

JOHN DALY, Consultant
October 23, 1958

80. Mechanics of Basin Evolution and its Relation to the Habitat of Oil in the Basin

KARL F. DALLMUS
November 10, 1958
(Joint meeting with Houston Geological Society)

81 Foreign Seismic Operations, and a Panel Discussion

JAMES D. ROOKUS, United Geophysical Corp.
GEORGE HARRINGTON, Independent Exploration Co.
F. J. AGNICH, Geophysical Service Co.
E. JOE SHIMEK, Geophysical Associates International
November 17, 1958

82. Ammonium Nitrate, Economy Blasting Agent for Oil Exploration

T. O. HALL, General Geophysical Co.
December 8, 1958

Abstract

Major savings for operators of seismic parties have been achieved by the use of prilled ammonium nitrate as a substitute for gelatin dynamite in areas where shot holes are dry. Pound for pound, the prills appear to have the same energy yield as 60 percent gelatin dynamite, and some improvement of records has been noted where prills are used. Safety problems are fewer with ammonium nitrate than with dynamite, and the development of efficient field handling techniques prevents the loss of production.

(Complete article in GEOPHYSICS v. 24, No. 1; 155-163; February 1959)

83. A Report on Alaska

J. BEN CARSEY, Humble Oil and Refining Co. and JOHN R. WOOLSON, United Geophysical Corp.
January 12, 1959

(See No. 17)

84. Outlining Salt Masses by Refraction Methods

ALBERT MUSGRAVE, Magnolia Petroleum Co.
January 19, 1959

Abstract

Short surface-to-surface refraction lines define the top of a shallow salt dome previously located by reflection methods. A map is made from the results of a number of longer refraction lines radiating from the center of the dome. The increased accuracy of this system is primarily dependent upon the accurate determination of velocities and distances.

Flank wells are used for further refraction shooting which yield more accurate velocity information and more detailed salt profiling. A map from this integrated information permits exploitation at a minimum risk, even though every location is essentially a wildcat.

(Complete article in GEOPHYSICS v. 25, No. 1; 141-167; February 1960)

85. Seismic Noise

M. R. MacPHAIL
February 16, 1959

(See No. 2)

86. The Elimination of Ghost Reflections

J. W. HAMMOND, Seismograph Service Corp.
March 16, 1959

87. Well Logging and Magnetic Tape

JOHN P. WOODS, The Atlantic Refining Co.
April 8, 1959

(See No. 36)

88. **The Resolution of Anomalous Masses**

E. V. McCOLLUM
May 8, 1959

(See No. 13)

89. **Magnetics in an Exploration Program with Particular Reference to Alaska**

R. A. GEYER, Geophysical Service Inc.
May 18, 1959

GEOPHYSICAL SOCIETY OF OKLAHOMA CITY
Oklahoma City, Oklahoma
(Chartered September 30, 1952)

90. **Seimic Prospecting—Facts, Fantasies and Economics**

H. M. THRALLS
September 15, 1958

(See No. 54)

91. **Geophysics and Stratigraphic Problems**

G. H. WESTBY
October 6, 1958
(Joint meeting with Oklahoma City Geological Society)

(See No. 3)

92. **Evaluation, Handling and Storage of Magnetic Tapes**

ROBERT B. FISHER
November 10, 1958

(See No. 3)

93. **Co-ordination of Continuous Velocity Surveys and Conventional Velocity Surveys—a symposium: Continuous Velocity Logging Method**

HOWARD BRECK, Seismograph Service Corp.

94. **Presentation of Velocity Miss-Tie**

W. B. ROBINSON, Gulf Oil Corp.

95. **Other Areas Where Miss-Ties Occur**

ROBERT NOLTING, Magnolia Petroleum Co.

96. **Possible Causes of Velocity Miss-Ties**

R. A. BRODING, Century Geophysical Corp.

97. **Limits of Accuracy of Present Sonic Logging Equipment**

F. P. KOKESH, Schlumberger Well Surveying Corp.

98. **Possible Methods of Eliminating or Adjusting Miss-Ties**

WARREN HICKS, Magnolia Petroleum Co.
March 3, 1959

99. Clevite Universal Seismic Analog Computer and Tape is Timely (two films)

March 16, 1959

100. Reflection Time and Structure—The Forward and Backward Conversion Illustrating Multiple Time Branches

JOHN BEMBROSE, Sohio Petroleum Co.
April 20, 1959

101. Recent Expeditions to the Antarctic

DANIEL LINEHAN, S. J., Boston College
May 4, 1959
(Joint meeting with Oklahoma City Geological Society)

102. Blasting Vibrations—Cause and Effect (a film)

May 18, 1959

JACKSON GEOPHYSICAL SOCIETY

Jackson, Mississippi
(Chartered May 12, 1955)

103. The Electronic Computer; A New Tool for Today's Seismic Interpreter

FRANK P. TROSETH, Magnolia Petroleum Co.
September 22, 1958

Abstract

The electronic computers available today provide geologists and geophysicists with a new tool for finding oil. The ability of these machines to process a large amount of data accurately and speedily makes them particularly helpful to the seismic interpreter. By recording well formation tops, well velocity survey data, seismic reflection times, and other basic geological and geophysical information an interpreter can obtain a wealth of information to aid him in his search for oil. Using the supplied information, an electronic computer can provide the interpreter with subsea depths, corrected reflection times, average velocities, interval thicknesses, or any other values which can be derived from the supplied information. The output data from a computer can be printed mechanically in the form of a table, graph, or map.

The examination of interval zones will probably be one of the most profitable activities made available to an interpreter who uses an electronic computer. Isopach information which has previously been available only after many hours of computation and drafting can now be requested almost at will. This means that the interpreter will be able to study many intervals investigating changes in velocity, wave travel time, and thickness. Studies of this type will certainly aid in the delineation of both stratigraphic and structural traps.

104. Geophysics and Stratigraphic Problems

G. H. WESTBY
October 27, 1958

(See No. 5)

105. The Dependence of Seismic Pulse Form and Frequency Content on Shot Variables

R. N. JOLLY and V. R. JOHNSON
January 26, 1959

(See No. 4)

106. The Evaluation, Handling and Storage of Magnetic Tapes

ROBERT B. FISHER
February 16, 1959

(See No. 3)

107. The Geological Significance of Mississippi Gravity Anomalies

MAYNARD P. JONES, Exploration Surveys, Inc.
April 27, 1959

MONTANA GEOPHYSICAL SOCIETY
Billings, Montana
(Chartered April 12, 1954)

108. Resolution of Anomalous Masses

E. V. McCOLLUM
September 8, 1958

(See No. 13)

109. Geophysics and Stratigraphic Problems

G. H. WESTBY
September 25, 1958
(Joint meeting with Billings Geological Society)

(See No. 5)

110. Velocity Log Characteristics

A. A. STRIPLING, Magnolia Petroleum Co.
November 4, 1958

111. Generation of Seismic Waves by Weight Drops

S. NORMAN DOMENICO, Pan-American Petroleum Corp.
December 8, 1958

(See No. 30)

112. Seismic work in Peru and Venezuela

R. H. MANSFIELD, Sohio Petroleum Co.
January 12, 1959

113. The Correction of Seismic Time Maps for Lateral Variations in Velocity Beneath The Low—Velocity Layer

C. HAROLD ACHESON, Imperial Oil Ltd.
February 2, 1959

(See No. 34)

114. The Mississippian in the Alberta Plains, and the Reflection Seismograph

GEORGE J. BLUNDUN, Home Oil Co., Ltd.
March 4, 1959

(See No. 35)

115. Studies of the Earth's Crust by Gravity and Seismic Methods and their Geological Significance

GEORGE P. WOOLARD, University of Wisconsin (Distinguished Lecturer)
March 31, 1959
(Joint meeting with Billings Geological Society)

116. Well Logs and Magnetic Tape

J. P. WOODS, The Atlantic Refining Co.
April 15, 1959

(See No. 36)

117. A Method for Obtaining Seismic Velocity Using Well Logs and Seismograms

S. C. MUT, The Atlantic Refining Co.
May 4, 1959

(See No. 41)

THE NEW MEXICO GEOPHYSICAL SOCIETY

Roswell, New Mexico

118. Qualitative Analysis of Multiple Reflections

W. S. HAWES
June 16, 1958

(See No. 42)

119. A Practical Interpretational Approach to Seismic Record Sections

C. N. PAGE, Continental Geophysical Co.
July 21, 1958

(See No. 16)

120. Development and Application of Magnetic Recording Technique and Instrumentation in the Field of Exploration Geophysics

ERNEST A. PRATT, Southwestern Industrial Electronics Co.
August 18, 1958

121. The Composition of Reflections

J. P. WOODS, The Atlantic Refining Co.
September 15, 1958

Abstract

When the traces on a seismic reflection record all show about the same deflection at about the same time, the line-up is marked and called a seismic reflection. An important fact is forgotten. The fact is that the reflection seen on the record is nearly always a composite of the various reflections caused by a set of closely spaced reflecting layers. When the arrangements of the layers

in the set changes, then the various reflections add together in a different way, and the character of the composite reflection seen on the record changes.

A series of artificial seismic records have been made to show this composition of reflections. The records were made by connecting a standard reflection seismograph to an acoustic model. The model was a three hundred foot length of steel pipe with input and output transducers at one end. Records were made for a wedge, a pinch-out, a complex of thin layers, a sand bar, layers corresponding to well resistivity logs, and a regular layer system.

122. Geophysics and Stratigraphic Problems

G. H. WESTBY
October 31, 1958
(Joint meeting with Roswell Geological Society)

(See No. 5)

123. Ghost Reflections

J. W. HAMMOND, Seismograph Service Corp.
November 17, 1958

124. An Empirical Velocity Determination in Southern Oklahoma

DONALD R. OKSA
December 15, 1958

Abstract

Lack of velocity data can sometimes be overcome by the proper co-ordination of seismic and geologic factors. The basic assumption that seismic and geologic data are directly correlatable must be utilized to its fullest extent. Upon this basis reliable basic seismic data of time and delta *t* values are computed with variations in the other parameters to make the computed seismic data closely match the known geologic conditions by one of several standard computing methods. The empirical fitting of the seismic data to match geologic conditions establishes the velocity gradient which can then be extrapolated into immediately adjacent areas. An iso-velocity section can also be prepared, if desired. Generally, it appears that iso-velocity contours parallel formational strikes. The application of such empirically derived velocity data will result in seismic structural maps and cross-sections which are compatible with actual geologic conditions. The value of the oftentimes neglected true dip section is shown and is actually an integral part of the analysis. The application of electronic computing techniques makes such determinations much more rapid and makes the method entirely feasible.

(Complete article in GEOPHYSICS v. 23, No. 4; 823-837; October, 1958)

125. Natural Phenomena as Applied to Oil Finding

H. M. THRALLS
January 19, 1959

(See No. 8)

126. Resolution of Anomalous Masses

E. V. McCOLLUM
February 25, 1959

(See No. 13)

127. "Ten Thousand Feet Deep" and "Trouble Lurks Below" (films)

March 16, 1959

128. A Method for Obtaining Velocity Control Using Well Logs and Seismograms

S. C. MUT
April 22, 1959

(See No. 41)

129. Limits of Accuracy of Present Sonic Logging Equipment

F. P. KOKESH, Schlumberger Well Surveying Corp.
May 18, 1959

PACIFIC COAST SECTION SEG
(Chartered April 12, 1958)

130. The Use of a Car-Borne Scintillation Counter in Locating the Surface Trace of Faults In The San Joaquin Valley

V. L. VANDERHOOF, Intex Oil Co.
October 9, 1958

Abstract

The results of eight months of field tests of this new geophysical field technique were reviewed. Several thousands of miles of gamma-ray profiles were studied and their salient features compared with known geology. Consideration was given to the effect of crops, fertilizers and other surface conditions on gamma-ray background measurements. The technique has yielded some very promising results.

PAPERS PRESENTED AT THE ANNUAL FALL MEETING
November 6-7, 1958

131. The Variation of Reflected Pulse Shape with Horizontal Distance

C. H. DIX, California Institute of Technology

Abstract

The assumption that reflected pulse shape does not vary with horizontal distance is, for most purposes, essentially correct. This theoretical study is designed for applications such as reflection velocity profiling which may require greater precision.

132. Offshore Singing—Field Experiements and Theoretical Interpretation

G. C. WERTH, D. T. LIU, A. W. TROREY, California Research Corporation

Abstract

Results from field experiments indicate that reflections themselves excite an acoustic resonant layer formed by the ocean surface and bottom, producing the sinusoidal "singing" waves.

133. The New Look in Refraction Shooting

C. H. SAVIT, Western Geophysical Company

Abstract

New technique and goals have produced a revival of refraction shooting.

Record section presentations and rapid computation procedures have shifted emphasis from complex and laborious calculations to geological-geophysical interpretive thinking.

134. Evaluation of a Model Seismology Technique

J. W. C. SHERWOOD, California Research Corporation

Abstract

Excellent agreement of theoretical and experimental results indicate the success of a particular model technique utilizing a small explosive charge as source and a condenser phone as detector.

135. Model Seismology at Cal Tech

J. H. HEALY, California Institute of Technology

Abstract

Discussion of the techniques used at Cal Tech with illustrations from a number of problems studied.

136. Soviet Research in Exploration Seismology

FRANK PRESS, California Institute of Technology
November 6, 1958

137. Lighting Warning For Geophysical Field Crews

P. B. MacCREADY, Meterology Research, Inc.
December 11, 1958

Abstract

Dr. MacCready described and showed movies of his research into the causes of lightning. He also described devices which can be used to give warning of lightning danger.

138. Possible Petroleum Provinces in Alaska

MAX BIRKHAUSER, Shell Oil Co.
January 8, 1959
(Joint meeting with AAPG Southern Section)

An Humble Oil and Refining Co. film, "Operation Alaska", was shown.

139. Geological and Gepohysical Exploration in Turkey

EKREM GOKSU, Technical University of Istanbul
February 12, 1959

PAPERS PRESENTED AT THE ANNUAL SPRING MEETING

April 14, 1959

140. Construction and Erection of the Standard-Humble Offshore Drilling Platform at Summerland

ROGER ALEXANDER,Standard Oil Company
March 12, 1959

141. The Prediction of Lightning: Its Relation to Seismic Operations

PAUL B. MacCREADY, JR., Meteorology Research, Inc.

Abstract

Lightning danger can be inferred from measurements of the atmospheric potential gradient at the earth. The values and limitations of this forecast method was discussed. Dr. MacCready also reviewed recent developments in understanding the mechanism of charge generation in clouds.

142. Some Preliminary Results of a Gravity Survey in the Copper River Basin, Alaska

D. F. BARNES, U.S. Geological Survey

Abstract

A simple Bouguer anomaly map was prepared from gravity observations made during the summer of 1958. In particular, Mr. Barnes discussed the three distinct gravity "lows" appearing on the map.

143. Techniques for Improving Seismic Interpretations

H. W. MENARD, JR., Scripps Institution of Oceanography

144. Techniques for Improving Seismic Interpretations

R. S. FINN and R. W. MOSSMAN, Seismograph Service Corporation

Abstract

A more complete and accurate interpretation of seismic data can be obtained through use of modern recording, display, and analysis techniques. These new methods provide greater stratigraphic and structural information and better evaluation of unwanted energy. Mr. Mossman (presented paper) showed specific examples.

145. Proton Free Precession Magnetometers

LEE LANAGAN, Varian Associates

Abstract

As the nuclear magnetic resonance theory developed in the early 1950's it was found that the precessional frequency of the proton about the axis of a magnetic field is dependent upon the strength of that field. Mr. Langan described instruments that measure this frequency, thus determining absolute values of the total intensity of the earth's magnetic field.

146. Review of Turkish Geological Exploration

EKREM GOKSU, Technical University, Istanbul

Abstract

Systematic geological studies in Turkey started with the foundation of the Turkish Geological Survey (MTA) in 1935. MTA prepared the first complete geological map of Turkey in 1942-46 and will publish a new one within five years. MTA was responsible for petroleum exploration until 1956. Now, however, this can and is also being done by private and foreign companies.

147. The Age of Earth

CLAIRE PATTERSON, California Institute of Technology

Abstract

The age of the earth is now known with some certainty. It is computed to be 4.5 billion years. This dating of the earth's origin is obtained by comparing the lead isotopes from meteorites with those found in rocks of the earth.

148. Liquid Core of the Earth

DR. LEON KNOPOFF, U.C.L.A.
May 12, 1959

Abstract

The earth's outer core is generally taken to be a liquid with an inner core of unspecified properties. Dr. Knopoff summarized our present state of knowledge of the cores. both inner and outer, with reference to the degree of rigidity, motion of the fluid parts, temperature, pressure, density and chemical composition.

149. The Constant Quest (Film)

ROBERT ZAVADIL, Western Gulf Oil Company
June 11, 1959

150. Radiation Surface Surveys for Finding Faults

V. L. VANDERHOOF

(See No. 130)

PERMIAN BASIN GEOPHYSICAL SOCIETY
Midland, Texas
(Chartered January 30, 1950)

151. Accounting and Tax Aspects of Geophysical Expenditures

J. W. YARBRO
September 9, 1958

152. Russian Successes In Petroleum Exploration

PAUL WEAVER, A&M College of Texas
October 30, 1958

153. Nuclear Energy and Fossil Fuels

M. KING HUBBERT, Shell Oil Co.
November 11, 1958
(Joint meeting with West Texas Geological Society and AIME)

154. The Evaluation, Storage and Handling of Magnetic Tapes

ROBERT FISHER
January 26, 1959

(See No. 3)

155. Seismic Noise

M. R. MacPHAIL
February 10, 1959

(See No. 2)

156. Ghost Elimination from Reflection Records

J. W. HAMMOND, Seismograph Service Corp.
March 10, 1959

157. The Geograph Today

ALAN WALDIE, McCollum Exploration Co.

REGINA GEOPHYSICAL SOCIETY
Regina, Saskatchewan, Canada

158. Scale In Exploration

O. C. CLIFFORD, The Atlantic Refining Co.

Abstract

"Scale" must be chosen with respect to the exploratory problem. When the derivation of the solution involves data of different units, a common and compatible unit must be found. This is as true of scale for economic problems in petroleum exploration as for technical problems. Examples from each field are given to show that the correct choice of scale will aid in the analysis of either problem.

159. Geophysics and Geopolitics

B. F. RUMMERFIELD, Century Geophysical Corp.

Abstract

A vast pool of technical ability and equipment is presently available for world wide usage in discovering petroleum reserves. This commodity is highly perishable, and it primarily depends upon proper incentive to survive. By proper incentive to survive. By "proper incentive" is meant a political and economic climate conducive to the employment of risk capital and thinking, without which oil cannot be found.

Whereas there is room for government-controlled exploration, the facts based upon world wide experience, give a tremendous advantage to the operations of private enterprise. Bureaucracies by nature are not suited to the risk aspect and tempo of the oil business.

Unless world wide exploration is properly stimulated by the withdrawal of political handicaps, domestic and foreign, not only will our technical assets wither, but also it is possible that world wide oil and gas reserves themselves will be wasted by simply not being found. No longer can a country afford to withhold oil prospects for the future. The countries that do will run a grave risk of competing with other sources of energy, such as atomic and solar, in the future.

160. The Future of Geophysical Exploration

J. P. WOODS, The Atlantic Refining Co.

161. Mississippian of the Alberta Plains and the Reflection Seismograph

GEORGE BLUNDUN

(See No. 35)

162. Evaluation, Handling and Storage of Magnetic Tapes

R. B. FISHER

(See No. 3)

163. Interpretation of Aeromagnetic Data

IZIDORE ZEITZ, U. S. Dept. Interior, Geophysics Branch

164. Correction of Seismic Time Maps for Lateral Variation in Velocity Beneath the Low Velocity Layer

C. H. ACHESON

(See No. 34)

SOUTH TEXAS GEOPHYSICAL SOCIETY

San Antonio, Texas

(Chartered November 9, 1953)

165. So Now You Have it on Tape

JOHN DALY
October 21, 1958

166. Seismic Velocities in South Texas—a Group Discussion Led by

P. E. NARVARTE
November 12, 1958

167. Ghost Elimination from Reflection Records

S. W. SCHOELLHORN, Seismograph Service Corp.
February 3, 1959

168. A Practical Interpretational Approach to Seismic Record Sections

C. N. PAGE
March 3, 1959

(See No. 16)

169. Qualitative Analysis of Multiple Reflections

W. S. HAWES
April 7, 1959

(See No. 42)

170. Evaluation, Handling and Care of Magnetic Tapes

ROBERT B. FISHER
May 5, 1959

(See No. 3)

SOUTHEASTERN GEOPHYSICAL SOCIETY

New Orleans, Louisiana

(Chartered April 1, 1954)

171. Point Plotting Using Electronic Computers

C. A. WOOD, Shell Oil Co.
September 15, 1958

Abstract

This paper describes a system for point plotting seismic cross sections, using a digital computer and a modified IBM type 407 accounting machine. The computer computes corrections to datum for each trace, corrects the reflection times and plots the cross-sections. Also, corrections are computed for normal stepout. The scale of the final cross-section is 1″ = 400'.

The time required to prepare cross-sections using the electronic computer is slightly greater than the time used in plotting sections by hand methods. This difference can probably be reduced by using short cuts in the preparation of data for the machine computations. The advantages of the system are (1) computing and plotting accuracy are improved, (2) isopachous cross sections can be made with relative ease, (3) after basic data have been read and punched, additional cross-sections plotted with different datum, correction velocity, or velocity distribution can be plotted with relative ease. This technique may be useful in special studies which involve problems that may be resolved through the use of interval cross-sections, or in areas where it is important to study the effect of changing velocities.

172. Decca Serves The Oil Industry

HENRY M. FAUST, Offshore Exploration Group
October 20, 1958

173. A Practical Interpretational Approach to Seismic Record Sections

C. N. PAGE
November 17, 1958

(See No. 16)

174. Fertilizer as a Source of Seismic Energy

J. W. COCHRAN, Atlas Powder Co.
December 15, 1958

175. Evaluation, Handling and Storing of Magnetic Tapes

ROBERT B. FISHER
January 19, 1959

(See No. 3)

176. Salt Dome Refraction Interpretation

A. W. MUSGRAVE
February 16, 1959

(See No. 84)

177. Relationship—Geology and Geophysics

J. P. WOODS, The Atlantic Refining Co.
March 16, 1959

178. Resolution of Anomalous Masses

E. V. McCOLLUM
April 20, 1959

(See No. 13)

179. Some Facts, Fantasies and Economics

H. M. THRALLS
May 15, 1959

(See No. 54)

SOUTHWEST LOUISIANA GEOPHYSICAL SOCIETY

Lafayette, Louisiana
(Chartered January 4, 1956)

180. Qualitative Analysis of Multiple Reflections

W. S. HAWES
September 16, 1958

(See No. 42)

181. Geophysics and Stratigraphic Problems

G. H. WESTBY
October 24, 1958

(See No. 5)

182. Outlining Salt Masses by Refraction Methods

W. C. WOOLEY, Magnolia Petroleum Corp.
November 17, 1958

183. Art: The Midas Touch to Geophysics

R. H. HOPKINS, Sun Oil Co.
January 19, 1959

Abstract

Geophysics, although based on sound physical reasoning, does not always admit a unique answer to a given problem. Unknowns such as hidden weathering, density contrasts, magnetic susceptabilities, etc., cause vague or incorrect answers. A partial remedy for this is the use of experience and common sense. Knowing when to take a few liberties with theory, and when to throw out some of the data can save many borderline jobs.

184. Geology and Geophysics of Northern Alaska

JOHN WOOLSON
February 3, 1959

(See No. 17)

185. Prospecting for Oil, Facts, Fantasies and Economics

H. M. THRALLS
March 3, 1959

(See No. 54)

186. Resolution of Anomalous Masses

E. V. McCOLLUM
April 21, 1959

(See No. 13)

187. Recent Expeditions to the Antarctic

DANIEL LINEHAN, S. J., Boston College
May 7, 1959

UTAH GEOPHYSICAL SOCIETY
Salt Lake City, Utah
(Chartered October 29, 1956)

188. Origin and Occurrence of Gulf Coast Hurricanes

A. H. GLENN
June 8, 1959

Abstract

The structure of hurricanes consists of a counter-clockwise rotating vortex of air several hundred miles in diameter and five to six miles in vertical extent, above which is superimposed an approximately clockwise rotating two to three miles in vertical extent.

Hurricanes are heat engines which are driven primarily by heat which is liberated when gaseous water vapor is condensed to rain. Dissipation of a hurricane occurs when the efficiency of the wind vortex is inhibited by friction or distortion such as movement of the hurricane over land areas or mountains, when the hurricane fuel, water vapor, fails to enter the vortex.

In connection with hurricane warning services for the gulf coast petroleum industry, approximately eighty tropical disturbances af varying intensities have been analyzed during their existence in the Gulf of Mexico during the past eleven hurricane seasons. It has been found that hurricanes form in one, or a combination, of six different types of weather situations. These types are:

1. Easterly Waves: The hurricane forms when a north-south oriented low pressure zone moves west across the tropics. The storm of September 4, 1949 was of this type.

2. Retrograde Low: The hurricane forms a low pressure area develops on a dissipating cold front over the southeast United States, and subsequently drifts southwest across the Gulf and acquires tropical characteristics.

3. Intertropical Convergence Zone: The hurricane forms when a low pressure area develops between the merging air streams of the tropics of the northern and southern hemispheres. Hurricane Flossy of 1956 was an example.

4. Low Aloft: The hurricane forms when a counter-clockwise rotating

vortex at altitudes of 10,000 to 20,000 feet develops down to the layers of air near the earth's surface. Storm Arlene of the past weekend was a combination of this type and the easterly wave type.

5. Induced Trough: The hurricane forms in a stationary zone of relatively low pressure between two high pressure areas of the subtropics. Hurricane Audrey of 1957 was an example of this type.

6. Modified Extratropical: The hurricane forms when a storm which commences development as a winter-type storm is insufficiently supplied with cold air and is modified to a tropical storm by overwhelming intrusion of moist tropical air. This type of tropical disturbance is rare. The storm of September 12, 1948 which moved inland southwest of Lafayette was of this type.

Research currently being conducted by the American Petroleum Institute, in which A. H. Glenn and Associates is participating, is directed towards methods of determining quantitatively the possibility of hurricane formation when one or a combination of these six types of weather situations exists over the Gulf of Mexico.

189. Geophysical Crew Organization and Supervision—an informal discussion

November 3, 1958

190. Geophysical Equipment and Methods—an informal discussion

December 1, 1958

191. Basic Principles of Velocity Logging

C. H. THURBER, Empire Geophysical Inc.
January 9, 1959

192. Sonic Logs with Relation to Porosity Determinations and Reservoir Analysis

CLIFF FERGUSON, Schlumberger Well Surveying Corp.
January 9, 1959

193. Synthetic Reflection Studies from Acoustic Logs

KENNETH S. TOWNSEND, Seismograph Service Corp.
January 9, 1959

194. Safety in Seismic Shooting Methods

DARRELL BROWN, Olin Mathieson Co. and
FRED WATSON, E. I. du Pont de Nemours and Co.
March 3, 1959

195. Exploration of Antarctica

DANIEL LINEHAN, S. J., Boston College
May 21, 1959

CONSTITUTION AND BY-LAWS

(*As amended to April* 10, 1958)

ARTICLE I

The name of this Society is the *Geophysical Society of Tulsa*. It shall be the Tulsa Section of the Society of Exploration Geophysicists.

ARTICLE II

OBJECT

The object of this Society is to promote the science of geophysics especially as it applies to exploration, and to promote fellowship and cooperation among those persons interested in geophysical problems.

ARTICLE III

MEMBERSHIP

1. Any person interested in the geophysical profession shall be eligible for membership.
2. Applications for membership shall be submitted in writing, and shall be signed by three sponsors who are members of the Society.
3. Application shall be approved for membership by the Executive Committee.
4. The annual dues of members of the Society shall be three dollars ($3.00) payable in advance on the first day of each calendar year.
5. Members whose applications are approved after July 1 shall be required to pay only one-half of the regular annual dues for the remainder of the first year of membership.
6. Charter Members of this Society will be those who attended the first organizational meeting of the Society on February 4, 1947, or who attended the second meeting on March 13, 1947, and signed the respective roll as charter members, and who have paid dues for the year 1947.
7. Honorary Members of this Society shall be elected by unanimous vote of the Executive Committee. To be eligible for Honorary Membership, a person must have attained the age of sixty and must have made outstanding contribution or contributions to the geophysical profession in general or to this Society in particular. Honorary Members shall receive all publications and meeting announcements of the Society but shall not be required to pay dues or any special assessments.

ARTICLE IV

RESIGNATION AND SUSPENSION

1. Any member may resign from the Society at any time. Such resignation shall be in writing and shall be accepted by the Executive

Committee, subject to the payment of all outstanding dues and obligations of the resigning member.

2. Any member who is more than one year in arrears in payment of dues shall be dropped from the Society. Any member, at his own option, may request in writing that he be dropped from the Society and such request shall be granted by the Executive Committee after due notification.

3. Any person who has ceased to be a member under Section 1 or Section 2 of the Article may be reinstated by unanmious vote of the Executive Committee subject to the payment of any outstanding dues and obligations which were incurred prior to the date when he ceased to be a member of the Society.

ARTICLE V

OFFICERS AND THEIR DUTIES

1. The officers of the Society shall be: President, First Vice-President, Second Vice-President, Secretary, Treasurer, and Editor.

2. There shall be district representatives to the Society of Exploration Geophysicists, as provided in the constitution of that society.

3. The Executive Committee shall consist of the Officers, the two most recent available Past Presidents, and the District Representative, or representatives, to the Society of Exploration Geophysicists.

4. The Officers shall be elected by a ballot as hereinafter provided at the Annual Meetings. The President, First Vice-President, Second Vice-President, Secretary, and Treasurer shall serve for one year. The Editor-elect shall serve for two years, the first year as Assistant Editor, the second year as Editor.

5. The President shall preside at the meetings of the Society and of the Executive Committee. He shall call special meetings when deemed advisable; shall appoint all committees except as otherwise herein provided; and, jointly with the Secretary-Treasurer, shall sign all written contracts and other obligations of the Society. In the temporary absence of other officers, he shall assume their duties or delegate them.

6. The First Vice-President shall be responsible for arranging the technical program of the Society, and shall have authority to appoint such assistants as he may require. He shall perform the duties of President in the absence or disability of that Officer, and in case of the President's resignation shall become President for the remainder of the term.

7. The Second Vice-President shall be responsible for arranging entertainment, and shall have power to appoint members to assist him.

8. The Secretary shall maintain a complete list of the membership of the Society and of its Executive Committee, shall mail advance notice of meetings to all members, shall keep minutes of meetings of the Society,

and of its Executive Committee, shall notify the members by mail of proposed amendments to the Constitution, and shall mail and receive ballots.

The Secretary shall submit to the Secretary-Treasurer of the Society of Exploration Geophysicists a report of each meeting of this Society and of its Executive Committee within two weeks following each such meeting. He shall also submit to the Secretary-Treasurer of the Society of Exploration Geophysicists the names of all Officers and Committee members within two weeks after their election or appointment.

9. The Treasurer shall collect all dues and other obligations to the Society, shall make disbursements authorized by the Executive Committee and shall transact such other business as may be authorized by the Executive Committee. He shall maintain a chronological record of all receipts and expenditures as well as a system of records explaining each expenditure, including evidence of authority to expend funds and evidence of payment. He shall report the condition of the Treasury at each Annual Meeting and at other times upon request of the Executive Committee.

   When so instructed by the Executive Committee, he shall make application to the Secretary-Treasurer of the Society of Exploration Geopsysicists for such portion of the expenses to be borne by that Society, as may be needed, and shall submit to the Secretary-Treasurer of the Society of Exploration Geophysicists, prior to the annual meeting of that Society, an itemized account of the expenditure of such funds as may have been received from the Society of Exploration Geophysicists during the preceding calendar year.

   A quorum of the Executive Committee shall consist of at least four members and approval by at least four members will be necessary to conduct all business of the Society.

10. The Editor shall be in charge of the editorial business, shall submit an annual report of such business, shall have authority to solicit papers and material for the regular society publication and for special publications, and may accept or reject material offered for publication. He may appoint editorial assistants.

11. The Executive Committee shall transact all business of the Society not otherwise herein specifically provided for. It shall elect all members to the Society, shall authorize all expenditures, shall direct investments of Society funds, shall establish and supervise publications; shall approve and recommend all proposals for special assessments; shall fill vacancies occurring in any office except in the office of President, to which the First Vice-President automatically succeeds, and shall have the power to review all actions and appointments by the Officers.

12. The District Representatives of the Society of Exploration Geophysicists shall represent the Society and its members at meetings of the Council of the Society of Exploration Geophysicists.

ARTICLE VI

ELECTION OF OFFICERS

1. A slate of nominations for officers shall be prepared by a Committee of Nominations consisting of the President and the two most recent available Past Presidents. They must secure the consent of all candidates nominated. This slate, of two or more candidates for each office, shall be prepared and announced to the Society at its regular meeting in March of each year.

   Additional nominations for each office may be made by written petition of ten or more members in good standing. Such nominations must be submitted to the President not later than the close of the regular meeting in April.

   The election of officers shall be by secret mail ballot. The Secretary shall mail to all members, not later than three weeks preceding the Annual Meeting, a ballot listing all candidates properly nominated for each office. Each member voting shall cast one vote for each officer and shall return his ballot to the Secretary in a sealed envelope carrying on the outside his written signature. Only ballots so prepared by members in good standing and received by the secretary by 4 P.M. on the Monday immediately preceding the Annual Meeting shall be valid.

   The Secretary shall indicate which ballots are valid and shall deliver them unopened to the Committee on Nominations. The Committee on Nominations shall supervise the counting of ballots prior to the Annual Meeting. The candidates receiving the greatest number of votes cast for an office shall be declared elected to that office. In case of a tie, the Executive Committee shall decide which of the tied candidates shall be elected.

2. The Committee on Nominations shall prepare a slate of nominations for any posts of district representatives to the Society of Exploration Geophysicists, which may need to be filled. Additional nominations may be made in manner set forth in Section 1. The election shall be by secret ballot at least three weeks prior to the annual meeting of the Society of Exploration Geophysicists.

ARTICLE VII

MEETING

1. The Annual Meeting shall be held in May of each year, and shall be held on the second Thursday of May, unless otherwise specified by the Executive Committee and due notice given to the membership.

2. The Regular meetings of the Society shall be held on the second Thursday of each month except during the months of June, July, and August, unless otherwise provided by the Executive Committee.

3. Special meetings may be called at any time by the President of the Society.

4. The time and place of regular meetings, the nature of the technical program and the entertainment, shall be determined by the Executive Committee.

ARTICLE VIII

AMENDMENTS

1. This constitution may be amended by a three-fourths vote of the members present at any regular meeting, provided that the proposed amendment has been approved for submittal by the Executive Committee and has been moved at a regular meeting previous to the meeting at which the ballot shall be taken.

2. By-laws may be changed by a majority vote of members present at any regular monthly meeting.

3. Nothing in this Constitution or By-laws shall be inconsistent with the Constitution and By-laws of the Sociey of Exploration of Geophysicits.

BY-LAWS

I. The Officers and the Executive Committee may arrange for the affiliation with other duly organized groups or societies which by object, aims, constitution or practice are aiding, assisting, or developing the profession of geophysics or allied technology.

II. Until such time as a sufficient number of qualified Past Presidents has been created, so as to provide those members necessary to serve on the Executive Committee as provided in the constitution, these Executive Committee members shall be chosen by the Sociey by a majority vote from open nominations at the Annual Meeting.

III. Prior to the Annual Meeting the Treasurer shall close his accounts and submit them to a committee of three members of the Executive Committee designated by the President. These members shall audit the cash book.

The new Treasurer shall accept the Society funds by giving an entry to that effect in the cash book.

IV. The Society shall publish a journal. The journal shall be published at intervals designated by the Executive Committee. All reports to the Society by its officers and committees may be published in the journal. Each issue shall contain a membership list. Each issue shall list all committees. Original papers, reviews, abstracts, notes of information deemed by the Editor to be of interest to the members of the Society shall be published in the journal. The editor shall be the sole judge of whether such material is to be published. The Executive Committee may authorize the printing of the journal and may authorize financing and distribution of the journal.

V. The first editor may be elected at a regular session of the Society following passage of this by-law at a regular meeting.

VI In order to effect the transition from a one-year tenure to a two-year tenure, the incumbent Editor shall serve an additional year as Editor.

RULES FOR THE ADMITTANCE OF NEW MEMBERS

1. Any person interested in the geophysical profession shall be eligible for membership in the Geophysical Society of Tulsa.

2. Applications for membership shall be submitted in writing, and shall be signed by three sponsors who are members of the Society.

3. Applications shall be approved for membership by the Executive Committee.

Note: The Constitution was originally adopted March 13, 1947. It was amended January 8, 1948, November 11, 1958, February 9, 1950, November 13, 1952, and April 10, 1958. The By-Laws were amended February 9, 1950, and November 13, 1952,

GEOPHYSICAL SOCIETY OF TULSA
ACTIVE MEMBERSHIP ROLL
AS OF MAY 1, 1959

Abel, Karl W.	Mayes-Bevan Co. 305 Kennedy Bldg.	Tulsa, Okla.
Afra, Thomas S.	920 East Third Street	Tulsa 20, Okla.
Alcock, Charles W.	The Atlantic Refining Company 830 Kennedy Building	Tulsa 3, Okla.
Alexander, Warren A.	Jersey Production Research Co. 1133 North Lewis Avenue	Tulsa 10, Okla.
Algermissen, S. T.	Sinclair Research Labs, Inc. Box 3006, Whittier Station	Tulsa 8, Okla.
Allyn, Robert M.	Phillips Petroleum Co. 321½ Dewey	Bartlesville, Okla.
Andrews, H. H.	Seismograph Service Corp. P.O. Box 1590	Tulsa 1, Okla.
Arnold, Tapley G.	Geo-Seis, Inc. 515 Thompson Bldg.	Tulsa 3, Okla.
Ater, Bill E.	2856 East 42nd Place North	Tulsa 5, Okla.
Austin, A. C.	P.O. Box 1309	Casper, Wyo.
Baker, John T.	5342 East 30th Street	Tulsa 14, Okla.
Ballard, James A.	Cardinal Geophysical Co., Inc. 822 Union Center	Wichita, Kans.
Ballou, Albert L., Jr.	1102 Hunt Building	Tulsa 3, Okla.
Baltosser, Robert W.	Route #3	Broken Arrow, Okla.
Barthelmes, A. J.	Seismograph Service Corp. 709 Kennedy Bldg.	Tulsa, Okla.
Bass, B. L.	The Texas Co. 904 Philtower Bldg.	Tulsa 3, Okla.
Baum, Robert B.	Seismograph Service Corp. 1229 Texas Nat'l Bank Bldg.	Houston 2, Texas
Bayhi, Joseph F.	Jersey Production Research Company 1133 North Lewis Avenue	Tulsa 10, Okla.
Beck, Ronald E.	414 Bank Building	Bartlesville, Okla.
Bentley-Llewellyn, N. James	Century Geophysical Corporation 1333 North Utica	Tulsa 10, Okla.
Berry, Donald L.	1028 South Oak Street	Bartlesville, Okla.
Bevan, Mr. Thomas J.	914 American Airlines Bldg.	Tulsa, Okla.
Bike, Peter	Oil & Gas Journal 211 South Cheyenne	Tulsa 3, Okla.
Blackman, Bruce A.	4121 East 48th Place	Tulsa 5, Okla.
Blaisdell, J. R.	Seismograph Service Corp. P.O. Box 1590	Tulsa 1, Okla.
Blakey, Carl W.	Century Geophysical Corp. Jenkins Bldg., 515 South Main	Tulsa 3, Okla.
Bondurant, J. E.	400 W. Frank Phillips Blvd.	Bartlesville, Okla.
Bonnette, Ibrey T.	1515 South Carson	Tulsa 19, Okla.
Borman, Frank W.	Amerada Petroleum Corp. Box 2040	Tulsa 2, Okla.
Born, W. T.	136 Mohawk Blvd.	Tulsa 6, Okla.
Boucher, F. G.	Jersey Production Research Company 1133 North Lewis Avenue	Tulsa 10, Okla.
Bowditch, Charles P.	3424 East 56th Place	Tulsa 5, Okla.
Bowman, D. C.	620 S. 91st E. Ave.	Tulsa 15, Okla.
Bradford, Marshall D.	422 North Main Street	Tulsa 3, Okla.

Bradley, Mr. Robert B.	2745 S. Gary Drive	Tulsa 5, Okla.
Bradley, Mr. R. M.	Cities Service Oil Co.	Bartlesville, Okla.
Branisa, Frank	Jersey Production Research Company 1133 North Lewis Avenue	Tulsa 10, Okla.
Bratt, Mr. Curtis C.	Phillips Petroleum Co. Room 416, 1st Nat'l Bank Bldg.	Bartlesville, Okla.
Braun, Theodor H.	538 Mission Street	South Pasadena, Calif.
Breck, H. R.	Seismograph Service Corp. P.O. Box 1590	Tulsa 1, Okla.
Brinnon, W. B.	Box 1650	Tulsa 2, Okla.
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